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USDA

Dietary Guidelines Advisory Committee

Prepared for the Committee by the Agricultural Research Service

United States Department of Agriculture

August 2004

Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2005

To the Secretary of Health and Human Services and the Secretary of Agriculture

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DEPARTMENT OF HEALTH AND HUMAN SERVICES

DEPARTMENT OF AGRICULTURE

August 19, 2004

The Honorable Tommy G. Thompson
Secretary of Health and Human Services
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The Honorable Ann M. Veneman
Secretary of Agriculture
1400 Independence Avenue, S.W.
Whitten Bldg., Room 200A
Washington, D.C. 20250

Dear Secretaries Thompson and Veneman,

On behalf of the entire 2005 Dietary Guidelines Advisory Committee, I am very pleased to submit the "Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2005."

In your charge to our Committee you asked that we take a different approach from that of previous Dietary Guidelines Advisory Committees. Rather than just considering how the 2000 Dietary Guidelines should be changed, you asked that we conduct an evidence-based review of diet and health. Thus, we initially posed over 40 specific questions related to dietary guidance. We then thoroughly reviewed the scientific literature pertaining to those questions, analyzed national data sets, sought additional information from invited experts, and deliberated on the results. After dropping some questions because of incomplete or inconclusive data, we wrote conclusive statements and a comprehensive rationale for 34 of the original questions. This evidence-based analysis of the science formed the basis for the 9 major messages that the Committee believes should be conveyed in the *2005 Dietary Guidelines of Americans*. Although this approach was challenging and demanding for the Committee and Staff, we believe that the scientific documentation for our major messages is done more systematically and meticulously than that of previous Advisory Committees. Our process did not eliminate the need for scientific judgment in resolving issues characterized by conflicting information. However, the Committee considered such issues with care, and came to sound consensus on all questions.

During the Committee's deliberations an overall theme for our report emerged. Collectively, available scientific data show that Americans need to select a quality diet *while* staying within their calorie requirements to achieve optimum health. Because of sedentary lifestyles and poor food choices, many Americans exceed their caloric needs

without meeting their nutrient requirements. This not only causes obesity and related diseases, but it also leads to malnutrition. Specific recommendations are provided within the report to improve diet quality without exceeding caloric needs. Major changes in the food habits and lifestyles of Americans are required to achieve this goal. The Committee recommends that your respective Departments, charged with the responsibility for the health and nutrition of the nation, initiate a national effort to reverse our escalating trend towards poor nourishment and health in a land of plenty. This requires many changes throughout our Society. Most specifically, we must explicitly address the extraordinary health disparities documented among our most economically disadvantaged in comparison to our most economically advantaged. Improved access to nutrient-rich foods at home, schools, work-places, and restaurants, opportunities for physical activity in all neighborhoods, schools, and work-places, and widespread education regarding the impact of individual choices are examples of changes we must effectuate.

On behalf of the entire Committee, I wish to thank you for the opportunity to serve our fellow citizens in this way. Although the charge to our Committee seemed daunting at times, we learned a tremendous amount from serving and benefited personally from the process. We appreciate your trust in us to accomplish this important task of making a contribution to the health of all Americans. I especially wish to thank you for assembling such an outstanding Committee with which to work on this endeavor. Every member made a unique contribution, and all committed themselves to the process. We truly enjoyed the camaraderie of working together on such an important mission.

I want to emphasize that this report could not have been completed without the excellent, diligent work of the Staff you provided. They were extremely dedicated and put in many long days and week-ends assisting the Committee. The hard work and extensive contributions of Carol Suitor need special recognition. Her guidance and assistance on how to present our information in a useful, readable manner were invaluable.

The Committee looks forward to the subsequent documents and discussion this report will generate. We believe that we have provided a strong foundation for that dialogue and work. We are very interested in the future dissemination of this information. Please do not hesitate to contact me or any of my colleagues should you wish to discuss this report with us.

Sincerely,

Janet C. King

Janet C. King, Ph.D.
Chair, 2005 Dietary Guidelines Advisory Committee

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Part A: Executive Summary

The *Dietary Guidelines for Americans* provide science-based advice to promote health and to reduce risk for major chronic diseases through diet and physical activity. By law (Pub. L. 101-445, Title III), the Secretaries of the Department of Health and Human Services (HHS) and the Department of Agriculture (USDA) issue a report at least every 5 years that "shall contain nutritional and dietary information and guidelines for the general public." Every 5 years, an expert Dietary Guidelines Advisory Committee is appointed to make recommendations to the Secretaries concerning revision of the *Dietary Guidelines for Americans*. The recommendations are to be targeted to the general public age 2 years and older and based on the preponderance of scientific and medical knowledge that is current at the time of publication of the Committee's report.

Because of its focus on health promotion and risk reduction, the *Dietary Guidelines* form the basis of Federal food, nutrition education, and information programs. By law, the *Dietary Guidelines* is to be "promoted by each Federal agency in carrying out any Federal food, nutrition, or health program." This means that the *Dietary Guidelines* must be applied in menu planning in programs such as the National School Lunch Program; in educational materials used by the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and by many other Federal programs; and in setting the *Healthy People* objectives for the Nation. Using the *Dietary Guidelines* helps policymakers, educators, clinicians, and others to speak with one voice on nutrition and health.

This report presents the recommendations of the 2005 Dietary Guidelines Advisory Committee to the Secretaries of HHS and USDA. It represents a milestone in documenting the scientific base used to develop the recommendations. The Committee used a fresh approach rather than simply considering how the year 2000 *Dietary Guidelines* should be changed. Committee members posed a large number of research questions. Questions were prioritized, and an extensive search of the scientific literature was done. Available time, expertise, and resources precluded an examination of all issues relating diet and physical activity to health promotion and chronic disease prevention.

Working through subcommittees, the Committee critically reviewed relevant scientific evidence, requested special analyses relating to nutrients and dietary patterns, obtained useful information and insights from invited experts and from public oral and written testimony, and deliberated on its findings. Since the general public now comprises large numbers of individuals with chronic health problems such as obesity, high blood pressure, and abnormal blood lipid values, as well as a large elderly population, the Committee addressed a few topics that may go beyond the dietary concerns of persons who meet strict definitions for good health. This report presents findings, conclusions, and recommendations from the entire Committee. Appendices and other materials posted at www.health.gov/dietaryguidelines provide additional details about the evidence used by the Committee.

The topics that the Committee addressed in depth included meeting recommended nutrient intakes; physical activity; energy balance; relationships of fats, carbohydrates, selected food groups, and alcohol with health; and consumer aspects of food safety. The Committee was especially interested in finding strong scientific support for dietary and physical activity measures that could reduce the Nation's major diet-related health problems—overweight and obesity, hypertension, abnormal blood lipids, diabetes, coronary heart disease (CHD), certain types of cancer, and osteoporosis. They developed the concept of discretionary calories in connection with calories and weight control; discretionary calories are those calories remaining within a person's caloric allowance after all nutrient recommendations are met. The Committee also focused on the potential health benefits and serious health risks of alcohol intake. Because food can promote health only if it is safe to eat and because foodborne illness affects more than 76 million Americans each year, food safety must undergird all dietary guidance.

Key Messages—Translating Scientific Findings Into Dietary and Physical Activity Guidance

The Committee's extensive review of the evidence and deliberations led to the development of a set of nine key messages. These messages should be useful to nutrition-related program providers, healthcare providers, and educators, as well as to those charged with the responsibility to produce the publication *Dietary Guidelines for Americans,* 2005 Edition. Part D of the report provides the scientific basis for the nine key messages. Part E provides specific recommendations for the content of the main messages and supporting details without specifying wording that would be suitable for consumers.

The Committee's findings support the development of *Dietary Guidelines* that convey the following nine major messages:

- Consume a variety of foods within and among the basic food groups while staying within energy needs.
- Control calorie intake to manage body weight.
- Be physically active every day.
- Increase daily intake of fruits and vegetables, whole grains, and nonfat or low-fat milk and milk products.
- Choose fats wisely for good health.
- Choose carbohydrates wisely for good health.
- Choose and prepare foods with little salt.
- If you drink alcoholic beverages, do so in moderation.
- Keep food safe to eat.

This list makes a major departure from previous editions of *Dietary Guidelines for Americans* in that it does not include a message specifically directed toward sugars. This does not mean that the current Committee views the topic of sugars to be unimportant. On the contrary, the Committee provides a strong rationale for limiting one's intake of added sugars (that is, sugars and syrups that are added to foods during processing or preparation or at the table). The Committee's intent is to make this point clearly under the new topic "Choose Carbohydrates Wisely for Good Health" and also under the first and second topics, which address energy needs and controlling calorie intake, respectively.

A synopsis of the Committee's recommendations regarding content to be included under each of the nine main messages follows.

Consume a Variety of Foods Within and Among the Basic Food Groups While Staying Within Energy Needs

Because the recommendations for nutrient intakes from the Institute of Medicine now consider the prevention of chronic disease as well as basic nutrient needs, meeting those recommendations provides a firm foundation for current health and for reducing chronic disease risk. Thus, meeting recommended nutrient intakes while staying within energy needs is a basic premise of dietary guidance. For most nutrients, intakes by Americans appear adequate. However, efforts are warranted to promote increased dietary intakes of vitamin E, calcium, magnesium, potassium, and fiber by children and adults and to promote increased dietary intakes of vitamins A and C by adults.

Choosing a variety of foods from within each of the basic food groups helps achieve recommended nutrient intakes, but attention to maintaining appropriate energy balance also is important. This means limiting calorie intake, especially from added sugars, solid fats, and alcoholic beverages—sources of calories that are very poor sources of essential nutrients.

Use of the revised USDA food intake pattern included in the report is one method to plan diets that meet recommended nutrient intakes considering age, gender, and physical activity level. This food pattern specifies recommended numbers of servings from the five food groups and from food subgroups. The foods in these groups are good sources of nutrients relative to the calories that they provide. The pattern allows a wide choice of foods within each food group and subgroup, and this report suggests ways to make substitutions across some of the food groups as well. Also included in this report are food lists of the best sources of nutrients that tend to be in short supply in the diets of Americans. These lists provide a useful way for consumers to choose foods they like to boost their intake of the nutrient; and they may be especially helpful for meeting recommended intakes of vitamin E, potassium, and fiber. Rather than simply adding nutrient-rich foods to one's diet, substituting nutrient rich foods for nutrient poor foods helps control calorie intake.

Special nutrient recommendations are warranted for a few large subgroups of the population as follows:

- Adolescent females and women of childbearing age need extra iron and folic acid.
- Persons over age 50 benefit from taking vitamin B_{12} in its crystalline form from foods fortified with this vitamin or from supplements that contain vitamin B_{12}.
- The elderly, persons with dark skin, and persons exposed to little UVB radiation may need extra vitamin D from vitamin D-fortified foods and/or supplements that contain vitamin D.

Control Calorie Intake To Manage Body Weight

Caloric intake and physical activity go hand in hand in controlling a person's weight. Caloric intake is emphasized under this message, physical activity under the next one.

To stem the obesity epidemic, most Americans need to reduce the amount of calories they consume. When it comes to weight control, calories *do* count—not the proportions of carbohydrate, fat, and protein in the diet. Energy expended must equal energy consumed to stay at the same weight. A deficit could be achieved by eating less, being more active physically, or combining the two. Since many adults gain weight slowly over time, even a small calorie deficit can help avoid weight gain. For example, a calorie deficit of 50 to 100 calories per day would enable many adults to maintain their weight rather than continuing to gain weight each year. For children who are gaining excess fat, a similar small decrease in energy intake can reduce the rate at which they gain weight so as they age they will grow into a healthy weight. Small changes maintained over time can make a big difference in body weight.

Monitoring weight regularly helps people know if they need to adjust their food intake or amount of physical activity to maintain their weight. Limiting the portion sizes that a person takes or serves to others often helps reduce calorie intake, especially if the food is high in energy density. On the other hand, consuming large portions of raw vegetables or low-fat soups may help limit one's intake of other foods that are more energy dense. The healthiest way to reduce caloric intake is to reduce one's intake of added sugars, solid fats, and alcohol—they all provide calories, but they do not provide essential nutrients.

Be Physically Active Every Day

Making moderate physical activity a part of an adult's daily routine for at least 30 minutes per day promotes fitness and reduces the risk of chronic health conditions such as obesity, hypertension, diabetes, and coronary artery disease. Walking at a brisk pace [3 to 4 miles per hour] is an example of a moderate physical activity. Moderate physical activity for an hour each day can increase energy expenditure by about 150 to 200 calories, depending on body size. If not offset by increased calorie intake, this increase in physical activity could be helpful in preventing weight gain. Many adults need to participate in up to 60 minutes of moderate to vigorous physical activity on most days to prevent unhealthy weight gain, while adults who have previously lost weight may need 60 to 90 minutes of moderate physical activity daily to help avoid regain of weight. Children and adolescents need at least 60 minutes of moderate to vigorous physical activity on most days for the maintenance of good health and fitness and for healthy weight gain during growth. Compared with moderate physical activity, vigorous physical activity provides greater benefits for physical fitness and burns more calories per unit time. Part D, Section 2, "Energy," addresses health benefits of additional types of physical activity.

Increase Daily Intake of Fruits and Vegetables, Whole Grains, and Nonfat or Low-Fat Milk and Milk Products

Fruits and Vegetables

Fruits contain glucose, fructose, sucrose, and fiber, and most fruits are relatively low in calories. In addition, fruits are important sources of at least eight additional nutrients, including vitamin C, folate, and potassium (which may help control blood pressure). Many vegetables provide only small amounts of sugars and/or starch, some are high in starch, and all provide fiber. Vegetables are important sources of 19 or more nutrients, including potassium, folate, and vitamins A and E.

Adults who increase their fruit and vegetable consumption to meet recommended nutrient intakes will also be consuming amounts of fruits and vegetables that are associated with a decreased risk of such chronic diseases as stroke, perhaps other cardiovascular diseases, type 2 diabetes, and cancer in certain sites. Moreover, increased consumption of fruits and vegetables may be a useful component of programs designed to achieve and sustain weight loss.

The suggested range of intake is 2½ to 6½ cups[1] of fruits and vegetables daily, depending on calorie needs. For persons needing 2,000 calories per day to maintain their weight, the goal is 4½ cups (or the equivalent) of fruits and vegetables per day. Consuming a variety of fruits and vegetables daily is recommended—choosing among citrus fruits, melons, and berries; other fruits; dark green leafy vegetables; bright orange vegetables; legumes; starchy vegetables; and other vegetables.

Whole Grains

Whole grains are high in starch, and they are important sources of 14 nutrients, including fiber. Diets rich in whole grains can reduce the risk of CHD and type 2 diabetes and help with weight control. Important sources of whole grains include whole wheat, oatmeal, popcorn, bulgur, and brown rice. Whole wheat bread is an example of a whole-grain food. The goal is to eat at least three servings (equivalent to 3 ounces) per day of whole-grain foods, preferably in place of refined grains.

Nonfat and Low-Fat Milk and Milk Products

Milk and milk products are important sources of at least 12 nutrients including calcium, magnesium, potassium, and vitamin D. Diets that provide 3 cups or the equivalent of milk and/or milk products per day can improve bone mass. This amount of milk product consumption may have additional health benefits and is not associated with increased body weight.

The goal for persons with energy requirements greater than 1,600 calories per day is 3 cups or the equivalent of milk products per day, preferably nonfat or low-fat products such as skim milk and yogurt. Milk products that are consumed in their nonfat or low-fat forms provide no or little solid fat and are very nutrient dense. When considering alternatives to milk, the most reliable way to derive the health benefits associated with milk products is to choose alternatives within the dairy food group such as lactose-free milk or yogurt (which may be lower in lactose than milk).

Choose Fats Wisely for Good Health

Keeping intake of saturated fat, *trans* fat, and cholesterol very low can help keep low-density lipoprotein (LDL) cholesterol low and reduce the risk of CHD. The main goals are to keep saturated fat intake below 10 percent of calories, *trans* fat intake below about 1 percent of calories, and cholesterol intake below 300 mg per day. Keeping saturated fat below 10 percent of calories should be the main focus, because this is the predominant fat in the American diet that adversely affects blood lipid values. However, the lower the combined intake of saturated and *trans* fat and the lower the dietary cholesterol intake, the greater the cardiovascular benefit will be.

The major way to keep saturated fat low is to limit one's intake of animal fats (such as those in cheese, milk, butter, ice cream, and other full-fat dairy products; fatty meat; bacon and sausage; and poultry skin and fat). The major way to limit *trans* fat intake is to limit the intake of foods made with partially hydrogenated vegetable oils. To limit dietary intake of cholesterol, one needs to limit the intake of eggs and organ meats especially, as well as limit the intake of meat, shellfish, and poultry and dairy products that contain fat.

A reduced risk of both sudden death and CHD death in adults is associated with the consumption of two servings (approximately eight ounces) per week of fish high in the n-3 fatty acids called eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). To benefit from the potential cardioprotective effects of EPA and DHA, the weekly consumption of two servings of fish, particularly fish rich in EPA and DHA, is suggested. However, it is advisable for pregnant women, lactating women, and children to avoid eating fish with a high mercury content and to limit their consumption of fish with a moderate mercury content. Consulting current consumer advisories helps one know which species of fish to limit or avoid in order to reduce exposure to environmental contaminants.

Total fat intake of 20 to 35 percent of calories is recommended for all Americans age 18 years and older. Intakes of fat outside of this range are not recommended for most Americans because of potential adverse effects on achieving recommended nutrient intakes and on risk factors for chronic diseases. The *lower* limit of fat intake is higher for children: 30 percent of calories from fat for children age 2 and 3 years, and 25 percent of calories from fat for those age 4 to 18 years. Part D, Section 4, includes conclusions relating to n-6 and n-3 polyunsaturated fatty acids and monounsaturated fatty acids, in addition to the fats listed here.

Choose Carbohydrates Wisely for Good Health

Carbohydrates—the sugars, starches, and fibers found in fruits, vegetables, grains, and milk products—are an

[1] See Tables D1-13 and D1-15 for information on 2 to 3 year olds.

important part of a healthful diet and the major energy source in most diets. Sugars and starches supply energy to the body in the form of glucose, which is the only energy source for the red blood cell and the preferred energy source for the brain, central nervous system, placenta, and fetus, and for muscle cells when they are operating anaerobically (without oxygen). Diets rich in dietary fiber help promote healthy laxation and help reduce the risk of type 2 diabetes and CHD.

When selecting foods from the fruit, vegetable, and grains groups, it is beneficial to make fiber-rich choices often. This means, for example, choosing whole fruits rather than juices and whole grains rather than refined grains. Current evidence suggests that there is no relationship between total carbohydrate intake (minus fiber) and the incidence of either type 1 or type 2 diabetes.

Following guidance to increase one's intake of fruits, vegetables, whole grains, and nonfat or low-fat milk or milk products is a healthful way to obtain the recommended amounts of carbohydrate. Compared with individuals who consume small amounts of foods and beverages that are high in added sugars, those who consume large amounts tend to consume more calories but smaller amounts of vitamins and minerals. Although more research is needed, prospective studies suggest a positive association between the consumption of sugar-sweetened beverages and weight gain. A reduced intake of added sugars (especially sugar-sweetened beverages) may be helpful in achieving the recommended intakes of nutrients and in weight control.

Sugars and starches supply substrate for bacterial fermentation in the mouth, and acids produced can cause tooth demineralization resulting in dental caries. However, drinking fluoridated water and/or using fluoride-containing dental hygiene products helps reduce the risk of dental caries. A combined approach is helpful for reducing caries incidence: reducing the frequency of consuming sugars and starches (e.g., limiting snacking on foods that contain these carbohydrates), limiting the length of time the teeth are exposed to fermentable carbohydrates, and optimizing oral hygiene practices.

Choose and Prepare Foods With Little Salt

Reducing salt (sodium chloride) intake is one of several ways that people can lower their blood pressure. Reducing blood pressure, ideally to the normal range, reduces the chance of developing a stroke, heart disease, heart failure, and kidney disease. The relationship between salt intake and blood pressure is direct and progressive without an apparent threshold. On average, the higher a person's salt intake, the higher is his or her blood pressure. Thus, reducing salt intake as much as possible is one way to lower blood pressure. Another dietary measure to lower blood pressure is to consume a diet rich in potassium. A potassium-rich diet also blunts the effects of salt on blood pressure, may reduce the risk of developing kidney stones, and possibly decreases bone loss with age.

The vast majority of the U.S. population consumes too much salt, much of it from processed foods. The goal is to consume less than 2,300 mg of sodium per day. The goal is expressed in terms of sodium rather than salt because the Nutrition Facts Label on food products lists sodium content. Many people—especially persons with hypertension, blacks, and middle and older-aged adults—will benefit from working toward a goal of an even lower sodium intake.

Reducing salt intake requires careful attention to food selection when shopping or when eating outside the home, and also during food preparation at home. The Nutrition Facts Label on food packages can help consumers compare and identify prepared foods that are lower in sodium.

Fruits, vegetables, and most milk products are widely available in forms that contain no added salt, and most of them are important sources of potassium. Increasing one's intake of foods rich in potassium helps lower blood pressure and blunts the effects of salt on blood pressure.

If You Drink Alcoholic Beverages, Do So in Moderation

Among middle-aged and older adults, the lowest all-cause mortality occurs at the level of one to two drinks per day. The mortality reduction is likely due to the protective effects of moderate alcohol consumption on CHD, primarily among males older than age 45 years and women older than age 55 years. Heavy drinking is very hazardous, contributing to automobile injuries and deaths, assault, liver disease, and other health problems. Abstention is an important option. Among younger people, alcohol consumption appears to provide little, if any, health benefit. Alcohol use among young adults is associated with an increased risk of traumatic injury and death.

The goal for adults who choose to drink is to do so in moderation. Moderation is defined as the consumption of up to one drink per day for women and two drinks per day for men. One drink is defined as 12 ounces of regular beer, 5 ounces of wine (12 percent alcohol), or 1.5 ounces of 80-proof distilled spirits.

Among the people who should not consume alcoholic beverages are those who cannot restrict their drinking to moderate levels, children and adolescents, and individuals taking medications that can interact with alcohol or who have specific medical conditions. Drinking alcoholic beverages should be avoided by women who may become pregnant or who are pregnant, by breastfeeding women, and by persons who plan to drive or take part in other activities that require attention, skill, or coordination.

Keep Food Safe To Eat

Foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year. Three pathogens (*Salmonella*, *Listeria*, and *Toxoplasma*) are responsible for more than 75 percent of these deaths. Actions by consumers can reduce the occurrence of foodborne illness substantially. The behaviors in the home that are most likely to prevent a problem with foodborne illnesses are

- Cleaning hands, contact surfaces, and fruits and vegetables (This does not apply to meat and poultry, which should not be washed.)
- Separating raw, cooked, and ready-to-eat foods while shopping, preparing, or storing
- Cooking foods to a safe temperature
- Chilling (refrigerating) perishable foods promptly
- Avoiding higher risk foods (e.g., deli meats and frankfurters that have not been reheated to a safe temperature [may contain *Listeria*]). This is especially important for high-risk groups (the very young, pregnant women, the elderly, and those who are immunocompromised).

Heeding All the Messages

Making any one of the recommended changes in diet, decreasing calorie intake, or increasing physical activity may improve health and reduce one or more health risks. However, the greatest benefits can be anticipated if one tries to heed all nine of the major recommendations. It is well recognized that multiple dietary factors and physical activity influence the risk of chronic diseases and that no one factor accounts for any of the chronic diseases.

The food pattern developed by the USDA and included in this report integrates most of the recommendations made by the Committee. This food pattern

- Is high in fruits and vegetables, whole grains, and nonfat or low-fat milk products
- Provides amounts of nutrients (including potassium and fiber) that are consistent with recommended nutrient intakes and with reducing the risk of chronic disease
- Is low in saturated fat, cholesterol, and added sugars and can be low in *trans* fat[2] and sodium[3]

A diet that is consistent with all of the diet-related recommendations in this report—the Dietary Approaches to Stop Hypertension (DASH diet)—has been demonstrated to have health benefits, including reducing blood pressure and LDL cholesterol. The DASH diet provides nutrients in recommended amounts and is very close to the revised USDA food intake pattern in the nutrients it provides. Thus, the finding that the DASH diet provides health benefits lends support to the combination of diet-related recommendations in this report.

Adding at least 30 minutes of moderate physical activity into one's daily routine would increase the calorie requirement by a small amount, allowing somewhat more leeway in the amount of food that could be consumed without gaining weight. Increasing physical activity would contribute to a lowering of chronic disease risk as well. Moderation in alcohol consumption, if used, also would reduce health risks. And taking measures to keep food safe to eat would reduce the risk of foodborne illness.

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[2] Currently, *trans* fat intake is not evaluated in the USDA food modeling method. However, limiting intake of solid fats as specified in the food intake pattern would be expected to help keep the intake of *trans* fats low.

[3] Special care is needed in the selection of processed foods and of foods consumed outside the home to keep sodium intake at or below the recommended level of 2,300 mg.

Dealing with Health Disparities and Contributions of the Environment

Health disparities are substantial among racial and ethnic minorities and among the economically disadvantaged. Available evidence suggests that certain dietary changes are a means to reduce these disparities. Social changes and educational efforts are required to facilitate healthful diets and lifestyles among these high-risk individuals.

In conducting the research on which this report is based, the Committee was struck by the critical and likely predominant role of the environment in determining whether or not individuals consume excess calories, eat a healthful diet, and are physically active. By environment we mean the constellation of cultural forces, societal norms, family influences (e.g., mealtime structure and parental feeding styles), changes in meal patterns, and commercial advertising that potentially influence individual behavior.

Environmental influences tend to be beyond the control of individuals. Examples include the large size of portions served by many food establishments, lack of information on calorie content at point of purchase, the high amount of sodium in the food supply, the *trans* fatty acid content of many ready-to-eat foods, the cost and availability of fruits and vegetables, and opportunities for safe and enjoyable physical activity. Thus, changes to the environment could make a substantial difference in consumers' ability and willingness to follow the guidance provided in this report.

Part B: Introduction

Since first published in 1980, the *Dietary Guidelines for Americans* has provided science-based advice to promote health and to reduce risk for major chronic diseases through diet and physical activity. The *Dietary Guidelines* is targeted to the general public over age 2 years who are living in the United States. Because of its focus on health promotion and risk reduction, the *Dietary Guidelines* forms the basis of Federal food, nutrition education, and information programs. By law (Public Law 101-445, Title III, 7U.S.C. 5301 et seq.), the most recent edition of the *Dietary Guidelines* is reviewed by a committee of experts, updated if necessary, and published every 5 years. This report presents the recommendations of the 2005 Dietary Guidelines Advisory Committee (DGAC) to the Secretaries of the Department of Health and Human Services (HHS) and the Department of Agriculture (USDA). The legislation also requires that the Secretaries of HHS and USDA review all Federal dietary guidance-related publications for the general public for consistency with the *Dietary Guidelines for Americans.*

The Role of Diet and Physical Activity in Health Promotion

Poor diet and a sedentary lifestyle contribute to about 400,000 of the 2 million or so annual deaths in the United States (Mokdad et al., 2004). Specific diseases and conditions linked to poor diet include cardiovascular disease (CVD), hypertension, dyslipidemia, type 2 diabetes, overweight and obesity, osteoporosis, constipation, diverticular disease, iron deficiency anemia, oral disease, and malnutrition (HHS, 1996; U.S. Preventive Services Task Force, 1996). Lack of physical activity has been associated with cardiovascular disease, hypertension, overweight and obesity, osteoporosis, diabetes, and certain cancers (World Health Assembly, 2004). Furthermore, muscle strengthening and balance training can reduce falls and increase functional status among older adults (World Health Assembly, 2004). Together with physical activity, a high-quality diet that does not provide excess calories should enhance the day-to-day health, vitality, energy, and a sense of well-being among most individuals.

The intent of the Dietary Guidelines Advisory Committee is to summarize and synthesize knowledge regarding many individual nutrients and food components into recommendations for an overall pattern of eating that can be adopted by the public. Several different indicators of diet quality have been developed to assess adherence to the *Dietary Guidelines for Americans.* Those indicators include the Recommended Foods Score (Kant et al., 2000), the Healthy Eating Index (Kennedy et al., 1994), and an Alternate Healthy Eating Index (McCullough et al., 2002). Although adherence to the *Dietary Guidelines for Americans* is low among the U.S. population, evidence is accumulating that selecting diets that comply with the guidelines reduces the risk of chronic disease. High scores on the Alternate Healthy Eating Index were associated with a 20 percent decrease in the risk of chronic disease in men and an 11 percent decrease in women (McCullough et al., 2002). Reductions in risk were particularly strong for CVD. Recently, Kant and co-workers reported that dietary patterns consistent with recommended dietary guidance were associated with a lower risk of mortality among individuals age 45 years and older in the United States (Kant et al., 2004). The authors estimated that about 16 percent and 9 percent of mortality from any cause in men and women, respectively, could be eliminated by the adoption of desirable dietary behaviors.

Although diet and physical activity influence health both together and separately, their joint effects have not been assessed, particularly the extent to which increased physical activity enhances the ability to meet nutrient guidelines. Physical activity is a fundamental means of improving the physical and mental health of individuals. Future studies of diet quality and health need to include measures of physical activity.

The *Dietary Guidelines for Americans* can be used to prevent the onset of targeted diseases (i.e., primary prevention), to improve health in individuals who have already developed risk factors or preclinical disease (i.e., secondary prevention), and to provide care for individuals with established disease (i.e., tertiary care) (U.S. Preventive Services Task Force, 1996). Both diet quality and physical activity appear to play important roles in preventing primary, secondary, and tertiary prevention.

The Role of Food Safety in Disease Prevention

Food will promote health only if it is safe to eat. Foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year (Mead et al., 1999). Three pathogens (*Salmonella*, *Listeria*, and *Toxoplasma*) are responsible for more than 75 percent of these deaths. Actions by consumers can reduce the occurrence of foodborne illness substantially.

The Role of Diet and Physical Activity in Reducing Health Disparities

Of substantial concern are disparities in health among racial and ethnic minorities and among different socioeconomic groups. For example, blacks tend to have a higher prevalence of elevated blood pressure and a greater incidence of blood pressure-related diseases, such as stroke and kidney failure, than nonblacks. Also, several subgroups of the population (e.g., Hispanics, American Indians, and blacks) have a strikingly high prevalence of overweight and obesity—even higher than the already high prevalence rates observed in the general population (see "Overweight and Obesity" below).

Dietary patterns differ among different groups. For example, individuals of lower education and income levels tend to eat fewer servings of vegetables and fruit than do those with more education and higher income. According to national surveys, blacks tend to have the lowest intakes of fruits and vegetables among ethnic and racial groups (HHS, 2004; USDA, 2004).

While the reasons for these differences are complex and multifactorial, this report addresses research indicating that certain dietary changes provide a means to reduce disparities. Part D, Section 7, "Fluid and Electrolytes," provides evidence that blacks tend to be more salt sensitive than nonblacks. Likewise, blacks tend to be more sensitive to the blood pressure lowering effects of increased potassium intake. Ironically, the average potassium intake of blacks is less than that of nonblacks. A healthful low-sodium, high-potassium dietary pattern, termed the Dietary Approaches to Stop Hypertension (DASH) diet (described in Part D, Section 1), has been shown to lower blood pressure to a greater extent in blacks than in nonblacks.

The effects on blood pressure of a reduced salt intake, increased potassium intake and an overall healthy dietary pattern provide an example of how dietary changes could reduce health disparities. Such evidence exemplifies important, yet under-appreciated, opportunities to reduce health disparities in minorities through dietary changes.

The Role of the Environment in Implementing the Guidelines

Ultimately, individuals choose the types and amount of food they eat and the amount of physical activity they perform. In conducting the research on which this report is based, the Committee was struck by the critical and likely predominant role of the environment in determining whether or not individuals consume excess calories, eat a healthful diet, and are physically active. By environment we mean the constellation of cultural forces, societal norms, family influences (e.g., mealtime structure and parental feeding styles), changes in meal patterns, and commercial advertising that potentially influence individual behavior.

In brief, the Committee believes that the current environment tends to encourage the over-consumption of calories and discourage the expenditure of energy. Changes in the environment and changes in individual behavior (but not changes in genes) are the driving forces that account for the obesity epidemic. Environmental factors that may contribute to excess calorie intake include, but are not limited to, the increased availability of energy-dense, nutrient-poor foods and beverages, expanding portion sizes, and increased consumption of meals outside the home. Environmental factors that discourage physical activity lead to reduced energy expenditures at school, work, and home. Among these factors are limited time for physical education, labor-saving devices, long work hours or commutes, and increased time in sedentary activities such as watching television, using computers, and playing video games.

In this report, we assess the impact of several of these environmental factors as well as the effects of individual food components and food groups on overweight and obesity (e.g., the roles of added sugars, fats, alcohol, fruits and vegetables, and dairy products). Not surprisingly, no single factor appeared to be responsible for the epidemic. Such findings reinforce the belief that multiple factors, rather than any one factor, are responsible for the obesity epidemic and that the optimal strategy to arrest the epidemic will be

multi-factorial. Teasing apart the relative importance of each factor is inherently difficult given the challenges of estimating calorie intake and energy expenditure on a population basis. Because many of these factors often are beyond the control of individuals (e.g., the size of portions served in food establishments and lack of information on calorie content at point of purchase), substantial changes to the environment are required to achieve a milieu that supports healthy behaviors.

Chronic Disease Risks Affected by Diet

The reduction of chronic disease risk merits strong emphasis in our Nation for many reasons. Among the leading causes of death in the United States in 2000 were poor diet and physical inactivity (400,000 deaths; 16.6 percent of total U.S. deaths) and alcohol consumption (85,000 deaths; 3.5 percent of total U.S. deaths) (Mokdad et al., 2004). Only tobacco accounted for a greater percentage of total U.S. deaths (18.1 percent). Poor diet and physical activity could overtake tobacco as a cause of death if the trend continues. Together, cancer, cardiovascular disease, and diabetes account for about two-thirds of all deaths in the United States and about $700 billion in direct and indirect costs annually (Eyre, 2004). An overview of specific diet-related causes of death and morbidity and of selected risk factors for some of these conditions is presented in the following sections.

Cardiovascular Disease

CVD[4] comprises coronary heart disease (CHD), the leading cause of death in the United States, cerebrovascular disease (also termed stroke, the third leading cause of death), and other conditions. In 2001, CVD accounted for 38.5 percent of all deaths or 1 of every 2.6 deaths in the United States. To put this in context, CVD accounts for more deaths than the next five leading causes of death combined, which are cancer, chronic lower respiratory diseases, accidents, diabetes mellitus, and influenza and pneumonia. While the occurrence of CVD typically occurs earlier in men than women, CVD is also the leading cause of death in women. In 2001, 32 percent of CVD deaths occurred before age 75 years.

The healthcare costs associated with CVD are staggering. The estimated direct and indirect costs in 2004 are projected to be $368.4 billion. Direct costs account for about $226.7 billion and include the cost of physicians and other professionals, hospital and nursing home services, medications, home health care, and other medical durables. Indirect costs account for the remainder and include lost productivity caused by CVD-related morbidity and mortality.

A substantial body of research has documented the importance of traditional CVD risk factors, which are extraordinarily common in the United States. Modifiable risk factors include elevated blood pressure, dyslipidemia, diabetes, and smoking. As documented in this report, several dietary factors and physical activity directly influence these risk factors or have independent effects on CVD. Hence, changes in diet and physical activity provide an important opportunity to delay, if not prevent, the occurrence of CVD.

Overweight and Obesity

Overweight and obesity in the United States among children and adults (Flegal et al., 2002) have increased at an alarming rate. The prevalence of obesity among adults has doubled in the past two decades (31 percent have a BMI > 30) (Flegal et al., 2002; Hedley et al., 2004). Overweight among children has doubled (7 percent in 1980 to 16.5 percent in 1999–2002), whereas overweight among adolescents has tripled (5 percent in 1980 to 16 percent in 1999–2002) (Hedley et al., 2004).

There is no significant difference in the prevalence of obesity among men across racial/ethnic categories for all age groups (Hedley et al., 2004). Among women at least age 20 years, the prevalence of obesity in 1999–2000 differed significantly between racial/ethnic groups, with non-Hispanic white women having the lowest prevalence (30.7 percent) and non-Hispanic black women having the highest (49.0 percent) (Hedley et al., 2004). The prevalence of obesity in non-Hispanic black men and women has increased from 21.1 to 28.1 percent and from 38.2 to 49.7 percent, respectively, in the past two decades, whereas, during the same time, obesity in Mexican American men and women increased from 23.9 to 28.9 percent and from 35.3 to 39.7 percent, respectively (Flegal et al., 2002). The prevalence of overweight among non-Hispanic black and Mexican American adolescents increased more

[4] The term total CVD, as used here, includes rheumatic fever/rheumatic heart disease; hypertensive diseases; ischemic (coronary) heart disease; pulmonary heart disease and diseases of pulmonary circulation; other forms of heart disease; cerebrovascular disease (stroke); atherosclerosis; other diseases of arteries, arterioles, and capillaries; diseases of veins, lymphatics, and lymph nodes; and other unspecified disorders of the circulatory system. Some congenital cardiovascular defects also are included. (American Heart Association, 2003, p. 3)

than 10 percent between 1988–1994 and 1999–2000 (Ogden et al., 2002). Data suggest that obesity is more prevalent among persons living in lower income households, especially among women (*Healthy People 2010*, 2000).

A high prevalence of overweight and obesity is of great public health concern because excess body fat leads to a much higher risk for premature death and for many serious disorders, including diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, stroke, gall bladder disease, respiratory dysfunction, gout, osteoarthritis, and certain kinds of cancers (NHLBI, 1998; Pi-Sunyer, 1993).

Elevated Blood Pressure

Elevated blood pressure is causally associated with several forms of CVD, including CHD (the leading single cause of death in the United States), stroke (the third leading cause of death in the United States), and congestive heart failure (the leading cause of hospitalizations among Medicare beneficiaries), and with kidney failure.

The contemporary classification of blood pressure has three major categories:

- Normal (systolic BP < 120 mmHg and diastolic BP < 80 mmHg)
- Pre-hypertension (systolic BP 120–139 mmHg or diastolic BP 80–89 mmHg)
- Hypertension (systolic BP $\geq$ 140, diastolic BP $\geq$ 90 mmHg, or use of anti-hypertensive medication)

Pre-hypertension affects approximately 22 percent of adults (or about 45 million people), whereas hypertension affects more than 25 percent of adults (approximately 50 million Americans) (Chobanian, 2003).

The prevalence of hypertension is increasing. According to U.S. survey data from the *National Health and Nutrition Examination Survey* (NHANES), the prevalence of hypertension in adults age 18 and older increased from 25 percent in 1988–1991 to 28.7 percent in 1999–2000 (Hajjar and Kotchen, 2003). The concomitant increase in weight between these periods only partially explained this trend. Hypertension prevalence was highest in blacks (33.5 percent), women (30.1 percent), and older persons (65.4 percent of persons age $\geq$ 60 years). It is estimated that approximately 90 percent of non-hypertensive adults will develop hypertension during their lifetime (Vasan et al., 2002). In a recent report, average blood pressure levels in children and adolescents age 8 to 17 years increased between NHANES surveys conducted in 1988–1994 and 1999–2000 (Muntner et al., 2004). In aggregate, these data indicate that elevated blood pressure is an extraordinarily common problem, one that is increasing in magnitude in the United States.

Evidence from numerous observational studies has documented a direct, progressive relationship between blood pressure and mortality from CHD and stroke (Lewington et al., 2002). The relationship between blood pressure and kidney disease also is direct and progressive (Klag et al., 1996). Strong support for efforts to reduce blood pressure comes from a combination of information: (1) the direct relationship of blood pressure with blood pressure-related cardiovascular-renal diseases and (2) the well-documented benefits of anti-hypertensive drug therapy. Efforts to reduce blood pressure are warranted in both non-hypertensive and hypertensive individuals.

Reduction in blood pressure and the prevention of hypertension in non-hypertensive individuals are vital and complementary components of public health strategies to prevent blood pressure-related chronic disease. A number of lifestyle modifications that help to control blood pressure are covered in this report. In non-hypertensive individuals, including those with pre-hypertension, lifestyle modifications have the potential to blunt the age-related rise in blood pressure and to lower the risk of blood pressure-related clinical complications. Indeed, even an apparently small reduction in blood pressure, if applied to an entire population, could have an enormous, beneficial impact on cardiovascular events. Stamler et al. (1989) estimated that a 3-mmHg reduction in systolic blood pressure could lead to an 8 percent reduction in stroke mortality and a 5 percent reduction in mortality from CHD.

Dyslipidemias

Dyslipidemias are abnormalities in the types and/or amount of cholesterol and triglycerides in the blood. Of the various lipid abnormalities, an elevated concentration of low-density lipoprotein (LDL) cholesterol is especially important. Elevated LDL cholesterol is causally associated with CHD, the leading cause of death in the United States, and is considered to be a major risk factor for the disease. In addition, LDL cholesterol is the primary target for cholesterol-lowering therapies.

The Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) has defined the following categories for LDL cholesterol values (NCEP, 2002):

- Optimal: < 100 mg/dl
- Near optimal/above optimal: 100–129 mg/dl
- Borderline high: 130–159 mg/dl
- High: 160–189 mg/dl
- Very high: 190 mg/dl

These recommendations were recently revised (Grundy et al., 2004). The major modifications follow:

- In high-risk persons, the recommended LDL cholesterol goal is less than 100 mg/dl.
- When risk is very high, the LDL cholesterol goal is less than 70 mg/dl (considered a therapeutic option).
- For more moderately high-risk persons, the recommended LDL cholesterol goal is less than 130 mg/dl, but an LDL cholesterol goal of less than 100 mg/dl is a therapeutic option.

Elevated serum LDL cholesterol levels are widely prevalent in the United States. Based on data collected from 1988 to 1994, at least 25 percent of all adult men and women over the age of 20 have LDL cholesterol levels above 130 mg/dl. More than 50 percent of men age 35 to 74 and women over age 55 had LDL cholesterol levels above 130 mg/dl (NCEP, 2002). According to NHANES data collected from 1988 to 1994 and then from 1999 to 2000, serum total cholesterol in the U.S. population decreased from 205 mg/dl to 203 mg/dl (Ford et al., 2003). Changes in LDL cholesterol would be expected to parallel serum total cholesterol changes observed in the population during this time span. This very modest decrease in mean total (and LDL) cholesterol values reinforces the importance of public health interventions to reduce this major coronary disease risk factor.

Epidemiologic studies have shown a progressive, dose-response relationship of serum total and LDL cholesterol levels with CHD risk (Stamler et al, 1986). Numerous clinical trials have shown that a reduction in LDL cholesterol concentration translates into a reduction in CHD incidence. For every 1 percent decrease in LDL cholesterol there is a corresponding 1 to 2 percent decrease in CHD risk (NCEP, 2002). The relationship between elevated LDL-cholesterol and the progression and development of CHD is a multistep process that begins early in life. LDL cholesterol lowering at all ages has beneficial effects on the risk of CHD. In early life, LDL cholesterol lowering delays, and even prevents, atherogenesis and subsequent plaque development. In later life, reductions in LDL cholesterol can slow atheroprogression, and marked reductions can, in fact, even reverse atherosclerosis.

Diabetes

Diabetes mellitus is increasing in the United States. At present, some 18.2 million people, or 6.3 percent of the population, have diabetes. However, of these, only about 13 million are aware that they have the disease (National Diabetes Information Clearinghouse, 2003). There are three primary types of diabetes. Type 1 diabetes, present in 5 to 10 percent of persons with diabetes, is an autoimmune disease in which the body makes antibodies to the beta cells of the pancreas, thereby causing destruction of these cells and leading to a failure of secretion of insulin. Type 2 diabetes results from a combination of insulin resistance (an inability of insulin to carry out its function appropriately) and insulin deficiency (an inability of the beta cells to produce enough insulin). Some 90 to 95 percent of persons with diabetes suffer from this type of diabetes, and 80 to 85 percent of them are obese. Gestational diabetes affects about 4 percent of pregnant women (about 135,000 cases per year) (American Diabetes Association Web site, 2004).

Diabetes leads to a number of serious complications. It is the leading cause of blindness in the United States today. Diabetes also is a leading cause of kidney failure and the leading diagnosis of patients requiring kidney dialysis. Compared with persons without diabetes, persons with diabetes are more than twice as likely to suffer from heart attacks and have a 2 to 4 times greater risk for stroke. More than 60 percent of nontraumatic amputations are related to complications from diabetes. Diabetes is the sixth leading cause of death in this country, and more than half of these deaths are due to heart disease. According to 2002 estimates, the health costs of diabetes in the United States were calculated at $132 billion ($91.8 billion direct and $40.2 billion indirect) (Brandle et al., 2003).

Metabolic Syndrome

The metabolic syndrome is defined by the presence of a collection of metabolic risk factors in an individual. The root causes of metabolic syndrome

are overweight/obesity, physical inactivity, and genetic factors. Various risk factors have been included in metabolic syndrome. Factors generally accepted as being characteristic of this syndrome include abdominal obesity, atherogenic dyslipidemia, elevated blood pressure, insulin resistance with or without glucose intolerance, prothrombotic state, and proinflammatory state.

Cancer

Cancer is a general term for diseases in which abnormal cells divide uncontrollably in various organ systems of our body. These cells can invade nearby tissues and spread through the bloodstream and lymphatic system to other areas of the body (NCI, 2004). It has been estimated that more than 1.3 million people will be diagnosed with cancer, and more than one-half million will die from cancer in 2004 (ACS, 2004).

Among Americans, the risk of developing and dying from cancer declined from 1975 to 2001 (ACS, 2004). The overall observed cancer incidence rate dropped 0.5 percent per year from 1991 to 2001, and the overall death rate from all cancers combined decreased 1.1 percent per year from 1993 to 2001. Death rates decreased for 11 of the top 15 cancers in men and 8 of the top 15 cancers in women. The incidence declined in men for lung, colon, oral cavity, leukemia, stomach, pancreas, and larynx cancers but increased for melanoma, prostate, kidney, and esophagus cancers. A decline in lung cancer incidence was noted for the first time in women. Incidence rates in women also declined for colon, cervix, pancreas, ovary, and oral cavity cancers but increased for breast, thyroid, bladder, kidney, and melanoma cancers (NCI, 2004).

This progress can be attributed to prevention, earlier detection, and better treatment; however, health disparities and wide variations in survival are observed among different ethnic and racial populations (Jemal et al., 2004). Many cancers are preventable, especially since nutrition and dietary practices, as well as adherence to healthy lifestyles, appear to be important in reducing the risk and mortality of cancer (Cerhan et al., 2004; Forman et al., 2004).

Osteoporosis

According to a World Health Organization definition (WHO, 1994), osteoporosis is characterized by reduced bone mass, increased bone fragility, and increased risk of fracture. Osteoporosis is a major health risk for Americans, with 10 million individuals already having osteoporosis and 18 million more having low bone mass, placing them at increased risk for this disease (NIH, 2000). The prevalence of osteoporosis among postmenopausal women in the United States is 21 percent in white and Asian, 16 percent in Hispanic, and 10 percent in black women (Looker et al., 1995).

In the United States each year approximately 1.5 million fractures are associated with osteoporosis, including 300,000 hip fractures, 700,000 vertebral fractures, 250,000 distal forearm fractures, and 250,000 fractures of other sites (Riggs and Melton, 1995). Among individuals at age 50, the risk of having a hip fracture at some point in the future is estimated at 17 percent for white women, 6 percent for black women, 6 percent for white men, and 3 percent for black men (Cummings et al., 1993; Melton et al., 1992).

Osteoporosis may be attributed to three factors: (1) accelerated bone loss at menopause in women or as men and women age; (2) suboptimal bone growth during childhood and adolescence, resulting in failure to reach peak bone mass; and (3) bone loss secondary to disease conditions, eating disorders, or certain medications and medical treatments (NIAMS, 2000).

Osteoporotic fractures, particularly vertebral fractures, can be associated with chronic disabling pain. Nearly one-third of patients with hip fractures are moved to nursing homes within the year following a fracture. Notably, one in five patients is no longer living 1 year after sustaining an osteoporotic hip fracture. Hip and vertebral fractures are a problem for women in their late 70s and 80s, wrist fractures are a problem in the late 50s to early 70s, and all other fractures (e.g., pelvic and rib) are a problem throughout postmenopausal years (NIH, 2000).

Direct financial expenditures for treatment of osteoporotic fracture are estimated at $10 billion to $15 billion annually. A majority of these estimated costs are due to inpatient care but do not include the costs of treatment for individuals without a history of fractures, nor do they include the indirect costs of lost wages or productivity of either the individual or the caregiver. Consequently, these figures substantially underestimate the true costs of osteoporosis (NIH, 2000). With the expected increase in the average age of the population, the incidence of hip fractures in the United States may triple by the year 2040 (Schneider and Guralnik, 1990).

Audience for Dietary Guidelines

The *Dietary Guidelines* is intended for the general public over age 2 years. Since the general public now comprises large numbers of individuals with chronic health problems such as obesity, high blood pressure, and dyslipidemias, the Committee considered topics beyond the dietary concerns of persons who meet strict definitions for good health. The populations addressed in the following sections posed special challenges regarding dietary guidance.

Children

Relatively few studies addressing the role of diet quality and physical activity in promoting health focus on children. Nevertheless, a high-quality diet, sufficient but not excessive in calories, and physical activity are integral in promoting the health, growth, and development of children. The rapid rates of growth occurring during adolescence increase the need for iron and calcium during that period to higher amounts per 1,000 calories than required at any other stage of life. In other words, the additional need for iron and calcium for growth is greater than the additional need for energy. Failure to achieve the recommended calcium intakes may reduce the peak bone mineral content and predispose the individual to osteoporosis later in life. Inadequate iron intakes increase the risk of iron-deficiency anemia, particularly among females. A nutrient-dense diet rich in milk and milk products, lean meats, poultry, fish, and legumes is needed to meet the calcium and iron recommendations during adolescence.

Moreover, it is important to address the needs of children when developing dietary guidance because development, extending from the fetal period through childhood and adolescence, can have a substantial influence on the risk of chronic disease. Furthermore, eating patterns established during childhood often are carried into adulthood (Aggett et al., 1994; Baranowski et al., 2000).

Recent research suggests that adult diseases may have their roots very early in life, even as early as the fetal period, as a result of inadequate nutrient intakes during pregnancy. According to the Barker hypothesis, low-birth-weight infants may have increased risk of heart disease, obesity, and type 2 diabetes as a result of conditions in the womb, or in the first few weeks of infancy (Barker, 2003). Childhood and adolescence also are critical periods for developing the antecedents of chronic disease. It is well recognized that peak bone development occurs during the pubertal period. Blood pressure rises through childhood and tracks into adult years. Evidence from autopsy studies of young soldiers has documented early evidence of atherosclerosis in persons under the age of 20. The high and increasing prevalence of overweight has markedly increased the prevalence of type 2 diabetes in children. As recently as 20 years ago, only 2 percent of all newly diagnosed cases of diabetes among youths age 9 to 19 were type 2 diabetes. Today, type 2 diabetes accounts for up to 50 percent of new cases of diabetes among youths. One in 400 youths, by the time they are 20, will have type 2 diabetes mellitus. Excess weight, particularly around the abdomen, as well as too little physical activity, appears to be the basis for developing this disease early in life. At least 2 percent of children have an inherited tendency toward high cholesterol levels known as familial hyperlipidemia, predisposing them to heart disease as an adult if not treated. In addition, children may adopt health behaviors that have a major influence on chronic disease, including dietary habits, physical activity, and smoking. In fact, 4.1 million children age 12 to 17 are already smokers, and nearly half of the children age 12 to 21 do not exercise on a daily basis.

Thus, children, as well as adults, are at risk for developing chronic disease because of a poor intrauterine environment, inherited tendencies toward the diseases, or an unhealthy lifestyle. Healthy lifestyles started at an early age (e.g., sensible eating and regular exercise) have the potential to diminish these health problems greatly. Childhood represents a sensitive time for developing healthful eating patterns. Studies have documented that patterns of food and nutrient intake track from childhood into later years, including adulthood. When 5 to 6 year olds were followed for 2 years, the correlations between initial and subsequent distribution of energy from macronutrients were statistically significant, ranging between 0.46 and 0.65 (Kemper et al., 1999; Nader et al., 1995; Singer et al., 1995; Stein et al., 1991). Other studies suggest that the intake of micronutrients also tracks from childhood to later years of life (Kelder et al., 1994; Moilanen et al., 1987; Nicklas et al., 1991; Singer et al., 1995). For example, fruit and vegetable consumption (Resnicow et al., 1998) and dairy food intake in childhood both show a moderate degree of tracking with age (Dwyer et al., 1989; Skinner et al., 2003; Teegarden et al., 1999; Welton et al., 1997). In other words, those who consume fruits and vegetables or milk regularly as children are more likely to do so as adults.

Pregnant and Lactating Women

Both pregnancy and lactation are critical periods during which maternal nutrition is a key factor influencing the health of both child and mother. Since physiologic adaptations to increased nutrient demand occur during both of these periods, the dietary need for nutrients is similar to that of nonpregnant women of comparable age (IOM, 1991). However, diet quality during pregnancy may influence fetal growth (see the section on children presented earlier). Certain dietary factors, including folic acid intake, may be especially important for normal development of the embryo and fetus during the first 3 months of pregnancy. Dietary factors may contribute to impaired glucose tolerance, a common disorder of pregnancy (Clapp, 1998; Saldana et al., 2004). Dietary contaminants, such as methylmercury, may adversely affect fetal growth. Maternal diet also may influence breastmilk composition somewhat, especially the milk's content of certain vitamins and alcohol (IOM, 1991).

Older Persons

The 2000 U.S. Census Report showed that about 13 percent of the U.S. population, or about 1 in 7, are over age 65. In 2011, the "baby boom" generation will begin to turn 65, and by 2030, it is projected that one in five people will be over age 65. Individuals age 85 and older are the fastest growing segment of the older population.

As the number of older Americans increases, the role of diet quality and physical activity in reducing the progression of chronic disease needs to be addressed in this population group. Furthermore, the process of aging can influence how nutrients are used and can exacerbate the effect of poor diet quality on health. For example, aging may reduce nutrient absorption, increase urinary nutrient loss, and alter normal pathways of nutrient metabolism. These changes associated with aging need to be compensated by dietary changes, which are discussed later in the report.

Most important, modifications of diet and increases in physical activity have tremendous potential as a means to prevent or delay chronic disease in older persons. First, the high absolute risk of chronic disease (e.g., high risk of stroke) is modifiable, not fixed. Second, older individuals achieve, in many instances, greater benefit from a given improvement in diet (e.g., older individuals tend to be more responsive to the blood-pressure-lowering effects of salt) or from an increase in physical activity. Third, it is well documented that older individuals can make and sustain behavior changes, including weight loss (DPP, 2002; Whelton et al., 1997).

Uses of *Dietary Guidelines for Americans*

A major goal of the 2005 Dietary Guidelines Advisory Committee was to use the available scientific base to characterize elements of guidance for a healthful diet—dietary guidelines that, if followed, will reduce the risk of chronic disease while meeting nutrient requirements.

The U.S. Government takes steps to promote health and reduce risk in its food assistance programs, nutrition education efforts, and decisions about national health objectives. For example, the National School Lunch Program and the Elderly Nutrition Program incorporate the *Dietary Guidelines* in menu planning; the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) applies the *Dietary Guidelines* in its educational materials; and the *Healthy People 2010* objectives for the Nation include objectives based on the *Dietary Guidelines*. Using the *Dietary Guidelines* helps policymakers, educators, clinicians, and others to speak with one voice on nutrition and health and to reduce the confusion caused by mixed messages in the media.

Summary

In this report, the Dietary Guidelines Advisory Committee integrates scientific evidence on diet, physical activity, and health into a set of conclusions and recommendations to be used as the basis for a revision of the *Dietary Guidelines for Americans.* The guidelines will provide steps that individuals can take toward achieving good health and well-being—both in the present and well into the future. Since the nutrient needs and risks of developing disease differ from person to person, the response to selecting a diet consistent with the *Dietary Guidelines* will vary among individuals. Some may enjoy a substantial health response to the dietary changes, whereas others may still develop elevated blood lipids, high blood pressure, or high blood glucose values. Differences in genetic backgrounds likely contribute to the divergent responses. However, irrespective of diverse biochemical and disease response to the dietary changes, improving diet quality and physical activity can substantially improve public health by reducing the risk of chronic disease.

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Part C: Methodology

Committee Appointment

Beginning with the 1985 edition, the Department of Health and Human Services (HHS) and the Department of Agriculture (USDA) have appointed a Dietary Guidelines Advisory Committee (DGAC) of prominent experts in nutrition and health to assist in the preparation of the *Dietary Guidelines for Americans*. This Committee has been an effective mechanism to obtain a competent review of the science, recommendations from experts, and broad public acceptance of the *Dietary Guidelines*. The 2005 DGAC was established for the single, time-limited task of reviewing the 2000 edition of *Nutrition and Your Health: Dietary Guidelines for Americans* and determining if, on the basis of current scientific and medical knowledge, a revision was warranted. The Committee determined that a revision was warranted and developed nutrition and health recommendations in this report for presentation to the Secretaries of HHS and USDA. The Committee was dissolved upon delivery of this report.

Nominations were sought from the public through a *Federal Register* notice published on May 15, 2003, and from Federal agencies. Prospective members of the DGAC were expected to be knowledgeable of current scientific research in human nutrition and be respected and published experts in their fields. They would be familiar with the purpose, communication, and application of the *Dietary Guidelines* and have demonstrated interest in the public's health and well-being through their research and/or educational endeavors. Expertise was sought in specific specialty areas, including, but not limited to, cardiovascular disease, cancer, pediatrics, gerontology, epidemiology, general medicine, overweight and obesity, physical activity, public health, nutritional biochemistry, nutrient bioavailability, nutrition education, and food safety and technology.

The Secretaries of HHS and USDA jointly selected individuals for membership to the DGAC. The individuals selected are highly respected by their peers for their depth and breadth of scientific knowledge of the relationship between dietary intake and health. The expertise of these individuals addresses all the relevant areas of the current *Dietary Guidelines for Americans*.

To ensure that recommendations of the Committee took into account the needs of the diverse groups served by HHS and USDA, membership included, to the extent practicable, individuals with demonstrated ability to represent minorities, women, and persons with disabilities. Efforts were made to ensure equitable geographic distribution and racial, ethnic, and gender representation. Appointments were made without discrimination on the basis of age; race and ethnicity; gender; sexual orientation; disability; or cultural, religious, or socioeconomic status. Equal opportunity practices, in line with HHS and USDA policies, were followed in all membership appointments to the Committee.

Charge to the 2005 Dietary Guidelines Advisory Committee

The *Dietary Guidelines for Americans* provides science-based eating and physical activity advice for healthy Americans over age 2 years. The DGAC shall advise the Secretaries of HHS and USDA whether revisions to the 2000 edition of *Nutrition and Your Health: Dietary Guidelines for Americans* are warranted on the basis of the preponderance of the scientific and medical knowledge currently available.

The Committee, whose duties are solely advisory and time-limited, will perform the following functions:

- If the Committee decides that no changes are necessary, it will so inform the Secretaries of the Departments. This action will terminate the DGAC.
- If the Committee decides that changes are warranted on the basis of the preponderance of the scientific and medical knowledge, the Committee will determine what issues for change need to be addressed.
- The focus of the Committee should be on the review of the new scientific evidence.
- The Committee shall make and submit its technical recommendations and the rationale for these recommendations in a report to the Secretaries. The Committee's focus should be its recommendations and the supporting science rather than translating the recommendations into a communication document.

- Upon the submittal of the Committee's recommendations, the DGAC will be terminated.

The Committee Process

The Committee served without pay and worked under the regulations of the Federal Advisory Committee Act. It held public meetings, announced in the *Federal Register*, in Washington, DC in September 2003 and in January, March, May, and August 2004. Meeting summaries are available at www.health.gov/dietaryguidelines.

Written public comments were received throughout the Committee's deliberations. Those received before August 10, 2004, were shared with all Committee members. Comments with recommendations for the Committee received before May 12, 2004, are summarized in Appendix G-6. In response to a solicitation for oral comments, 31 organizations or individuals presented oral testimony during the January 28–29, 2004, meeting of the Committee. These comments are summarized in the January Public Meeting Summary (www.health.gov/dietaryguidelines). Comments are available for examination at the Office of Disease Prevention and Health Promotion, 1101 Wootton Parkway, Suite LL100, Rockville, MD, 20852.

To promote a fresh examination of the science base for dietary guidance, the content areas to be addressed differed somewhat from the topics of the 10 guidelines in the 2000 *Dietary Guidelines.* In particular, the workload was divided and managed by subcommittees on nutrient adequacy, carbohydrates, fats, fluid and electrolytes, energy, ethanol, and food safety. Midway through the effort, a macronutrient subcommittee was appointed to address some crosscutting topics, and a subcommittee was formed to address fruits and vegetables, grains, milk, and milk products. To aid in coordination and communication, a lead Committee member was appointed for each subcommittee, but the conclusions reached reflected the consensus of the entire group. One or more designated staff members from HHS or USDA assisted each subcommittee.

The Science Review Subcommittee was formed to help maintain consistent standards for the reviews across subcommittees. It also addressed quality standards for the entire process, including consideration of the format of the report to the Secretaries, integration of the various subcommittees' work into a cohesive document, and meeting plans.

The subcommittees communicated by conference call, e-mail, and face-to-face meetings. Each subcommittee was responsible for presenting the basis for its conclusions and recommendations to the full Committee, responding to questions, and making changes if indicated. To gain perspectives for interpreting the science, some subcommittees invited experts to respond to specific questions during conference calls. The full Committee heard presentations from 12 invited experts, who addressed questions posed by the Committee in advance and responded to additional questions during the meeting. The conclusions in this report reflect the consensus of the entire Committee.

Research Questions

Each subcommittee generated an initial list of research questions that might be relevant to setting dietary guidelines. The subcommittee then set priorities based on the perceived level of importance and availability of literature. This process was iterative. Throughout the deliberations, the wording and intent of the research questions evolved, as did the need for additional questions. Available time, expertise, and resources precluded an examination of all issues related to the effects of diet on chronic disease.

Systematic Review of the Scientific Evidence

The DGAC relied on the published literature and, in a few instances, preprints of articles that had been accepted for publication and provided to the Committee by individual members and invited experts. Major sources of evidence were the *Dietary Reference Intake* reports prepared by expert committees convened by the Institute of Medicine (IOM). Other sources were systematic evidence-based reports such as the Agency for Healthcare Research and Quality report on omega-3 fatty acids and the World Health Organization International Agency for Research on Cancer (IARC) report on the relationship between fruit and vegetable intake and cancer. In addition to these comprehensive documents, the subcommittees relied on literature searches to identify pertinent articles on research questions not addressed in any evidence-based report and to update previously published evidence reports.

Types of Evidence

The Committee focused on studies conducted in humans. The primary types of studies used were observational studies and clinical trials. Specific types of observational studies were cross-sectional studies, case-control studies, and cohort studies. The Committee placed the greatest emphasis on results from cohort studies and trials with well-accepted, clinically relevant outcomes. Such outcomes included clinical diseases (e.g., incident cancer and myocardial infarction) and well-accepted risk factors (e.g., systolic blood pressure, low-density lipoprotein cholesterol, and weight). Meta-analyses also were considered. The majority of studies evaluated were based on adults; there were limited studies on children.

Literature Searches

Staff developed the search strategy in consultation with each subcommittee chair to meet the needs of that subcommittee. The search strategy included search parameters, search terms, search databases, and exclusion criteria (including years covered).

Typical exclusion criteria included the following: *in vitro* studies, animal studies, articles before "X" date, and drug studies. The specific exclusion criteria varied by question (e.g., questions involving cancer as an endpoint may not exclude animal studies). In some cases, additional references were identified by checking the reference lists of review articles. The years covered were influenced by the availability of evidence-based reviews that addressed the same topic. For example, the literature search regarding fiber covered only 1999 and later years because a prior IOM report covered the earlier years. Some searches were expanded if results from the initial research were meager.

Summaries of Results

The Science Review Subcommittee developed a prototype table to be used for summarizing information obtained from relevant articles for priority questions. Content included in the tables was to be concise, factual, and descriptive and to provide a basis for formulating tentative conclusions. Staff worked with the respective subcommittee chair to examine the search results and eliminate articles that were not relevant to the subcommittee's topic. They then extracted the key information and, by using the prototype, produced a table to cover key information about each question for which relevant articles were identified. See Appendix G-3 for working summary tables.

Critical Review of Studies

Subcommittee members read the tables and requested key articles. They then critically assessed study quality and relevance to the overall question being addressed. The subcommittee members, not the staff, made the decisions on study quality and on the relative value of clinical trials and observational studies. They considered these factors, along with the data summarized in the tables, in reaching tentative conclusions for consideration by the full Committee.

Preparation of Conclusive Statements

For each research question, subcommittees prepared a brief document that included a conclusion that specifically addressed the research question, a list of key sources, and a summary of key studies and findings. The subcommittee presented draft summary statements to the DGAC for consideration. Members of the Committee who were not members of the subcommittee were also assigned to review the statements and provide in-depth critical review. For especially controversial topics, the entire Committee examined the key published evidence on which a conclusion was based. At the May and August meetings, the whole Committee voted on the wording of each conclusion.

Use of the USDA Food Intake Pattern and Special Analyses

The Committee had access to the food pattern proposed by the USDA (*Federal Register* notice, vol. 68, no. 176, September 11, 2003, p. 53536) and to technical support data related to the pattern. This information included the following:

- A proposed daily food intake pattern that lists the daily amounts of food from each food group and subgroup for 12 age/energy groups.
- Energy levels for the proposed food intake pattern.
- Nutritional goals for the daily food intake pattern covering vitamins, minerals, and macronutrients.
- Nutrient profiles of the basic food groups and their subgroups and for additional fats, oils, soft margarines, and added sugars. The food groups and subgroups are composites that reflect the types

and amounts of foods commonly consumed by Americans.
- Nutrients provided by the proposed food pattern.

At the request of three subcommittees, USDA staff used its food modeling system to conduct several types of analyses. Most of these analyses involved the modeling of the food pattern intended to meet selected specifications for nutrient intake. For example, the subcommittees requested analyses to obtain information relevant to flexibility in the choice of food to meet nutrient needs, the effects of different fat intakes on the nutrients provided by the food pattern, and the approximate number of calories needed to meet recommended nutrient intakes. See Appendix G-2 for the descriptions of these analyses and their results.

The USDA food modeling process used in these analyses was developed originally for deriving the Food Guide Pyramid. It was updated for these analyses to include nutrient goals from the IOM *Dietary Reference Intakes* report that was released in 2004 (after the *Federal Register* notice regarding the proposed food pattern) and the most recent *National Health and Nutrition Examination Survey* (NHANES) 1999–2000 food consumption data. The USDA food modeling process involves the following steps:

1. *Establishing nutritional goals*. Goals were obtained from the *Dietary Reference Intakes* reports for various vitamins, minerals, macronutrients, and electrolytes released by the IOM between 1997 and 2004.
2. *Establishing energy levels*. The food pattern was developed for caloric levels from 1,000 to 3,200 calories per day in 200-calorie increments. The pattern was created for each age/gender group and was deemed applicable, whether individuals were sedentary or physically active.
3. *Assigning nutritional goals to each specific food intake pattern*. The specific nutritional goals assigned to each food intake pattern were the goals of age/gender groups with sedentary energy requirements that most closely matched the caloric level. For example, the goals of females age 31 to 50 years, males/females age 9 to 13 years, and females age 14 to 18 years matched the 1,800 calories per day level. In some cases the nutrient levels in a food pattern were compared to nutritional goals for several age/gender groups. For example, at the 1,800-calorie level, three goals were specified for each nutrient: those for females age 31 to 50 years, for males/females age 9 to 13 years, and for females age 14 to 18 years.
4. *Assigning a nutrient content to each food group and subgroup*. Foods included in each of the commodity food groups or subgroups (fruits, milk, meat and beans, whole grains, enriched grains, dark green vegetables, orange vegetables, legumes, starchy vegetables, and other vegetables) are based on the food consumption of Americans, with any food that represents 1 percent or more of the consumption from that group or subgroup included in the development of a nutrient profile. Other foods (less than 1 percent of group or subgroup consumption) are grouped with a similar food item for analysis. The nutrient profiles of each commodity group are the weighted averages of the nutrient content of foods in each food group according to consumption. The USDA Continuing Survey of Food Intakes by Individuals (CSFII) 1994–1996 was the source of food consumption data in the *Federal Register* notice, but the NHANES 1999–2000 food consumption data were used to determine new nutrient profiles for this analysis. Two-day food intakes from 14,262 individuals over age 2 years were weighted to represent the nationwide population. For example, the nutritional composition of dark green leafy vegetables reflected the nationwide consumption of foods falling into that group, which were about 53 percent broccoli and 20 percent spinach. Therefore, the nutritional value of the dark green leafy vegetable group was 0.53 of the nutritional value of broccoli, 0.20 of the value of spinach, and 0.27 other. Foods in their lowest fat form were selected for determining the nutrient profile of the milk and meat groups. For the milk group, fat-free milk was the single food item used to represent this food group. For the meat group, only the leanest cuts of meat, fish, and poultry prepared with all fat or skin removed were used. Eggs and nuts also were included in this group.
5. *Determining the daily intake amounts for each food group or subgroup*. Starting from the original Pyramid food pattern, the amounts of each food group or subgroup were increased or decreased in an iterative manner until the pattern for each calorie level achieved its nutritional goal or came within a reasonable range. A reasonable progression from pattern to pattern of the amounts recommended in each food group was maintained to make the pattern logical from an educational standpoint.

Because 12 different levels of energy intake ranging from 1,000 to 3,200 calories per day have been used, a person can select a food pattern according to his or her

level of physical activity. The pattern was developed for individuals with low, moderate, or active levels of physical activity.

There are advantages to the approach used in developing this food intake pattern. One advantage is that it provides continuity with previous food guidance and allows evolution of the guidance over time to build on what consumers already understand while updating the science base. Also, the approach provides an educational tool that integrates the gamut of IOM recommendations into a food intake pattern. That is, the approach assists in converting the full set of nutrient recommendations to food-based recommendations suitable for males and females of different ages and activity levels. The process has resulted in a food pattern that meets IOM recommendations for almost all nutrients at all calorie-intake levels.

There are disadvantages to the approach, however. First, the nutrient profile of each food group and subgroup is based on Americans' current consumption of foods within that group. Because Americans may not select rich sources of certain nutrients, the nutrient profiles for a group or subgroup also may be low in that nutrient. This makes it more difficult to develop models that meet the appropriate Dietary Reference Intakes for some nutrients. For example, Americans eat very few nuts relative to other choices in the meat, poultry, fish, dry beans, eggs, and nuts group; and the nuts they tend to eat are not especially rich in vitamin E. Therefore, the nutrient profile for "nuts" and for the entire meat, poultry, fish, dry beans, eggs, and nuts group is relatively low in vitamin E. This also is true for the types of oils that Americans tend to select; relatively few individuals use oils that are especially rich in vitamin E. When using the nutrient profiles for these food groups, it is difficult to develop a food intake pattern that meets the Recommended Dietary Allowance for vitamin E. This holds true even if only lacto-ovo vegetarian choices are made from the meat, poultry, fish, dry beans, eggs, and nuts group, by including only eggs, nuts, and legumes in the nutrient profile for this group. The same problem exists in trying to use these nutrient profiles to meet IOM recommendations for sodium and potassium, because the profiles rely on current consumption and the food supply, both of which are high in sodium and low in potassium.

Second, the five basic food groups used in the modeling stemmed from historical nutritional concerns: vitamin C (fruit), vitamin A (vegetables), calcium (milk), protein (meat), and energy (grains). The original 1992 Pyramid pattern considered and evaluated 21 different diet components (i.e., vitamins, minerals, different fats, and energy). The new dietary reference intakes include standards for a total of 27 diet components (vitamins, minerals, electrolytes, essential fats, all the macronutrients, and fiber). As with the original Pyramid development, this requires the use of more than the five basic food groups to meet the dietary reference intakes. Consequently for these analyses, vegetables were broken down into the following subgroups: dark green, deep yellow, legumes, starchy, and other. Grains were divided into whole and enriched grains. Meats and legumes were not divided into subgroups, however. The amounts from several of the various subgroups increased (e.g., dark green vegetables and legumes) to meet the new nutrient recommendations.

Third, persons using this pattern need to take great care to account for the (1) fat contained in milk products and meats, (2) fats and added sugars that are a part of processed foods (such as muffins or soft drinks) and are added when preparing or serving food, and (3) calories provided by alcoholic beverages. Otherwise, their intakes of calories and saturated fats are likely to be too high.

Although the food-modeling program was not perfect, it was a valuable tool for the Committee in determining how the food pattern could be developed to meet science-based criteria for a healthful diet.

Sources of Nutrients in American Diet

Several tables found in Parts D and E of this report present food sources of nutrients consumed by Americans. These tables, adapted from tables published by Cotton et al. (2004), draw upon CSFII 1994–1996 data. To confirm that the CSFII data are still representative, a prototype analysis of 1999–2000 NHANES food consumption data was run on one key nutrient—potassium. The analytical methodology and comparison follow.

The NHANES analysis included individual consumption records that were considered reliable and met the daily minimum (acceptable) number of foods consumed. The Cotton analysis used similar data from CSFII 1994–1996. The nutrient content of the individual foods were drawn from the USDA Nutrient Composition Database Standard Reference 16.1. The

two analyses incorporated similar food groupings. However, because time was short for completing the Committee's work, the prototype NHANES analysis did not disaggregate food mixtures to their basic ingredients, as the Cotton analysis did. Rather, in most cases, the most prominent ingredient in the food mixture dictated the category in which the food was placed. For example, the coffee category includes coffee with milk or other combinations and does not break down into the coffee and milk categories, as in the Cotton article. Similarly, the tomatoes from pizza do not appear in the tomato category because they are picked up in the multi-ingredient category called egg rolls, pizza, etc. An examination of the top 10 food contributors (shown in Table C1-1) indicates that there may be about a 5 percent difference when using the different approaches.

A comparison of the results from the two types of analysis indicates that the percent contribution by food category to the total potassium intake did not differ substantially. The reasons for differences may be due to the placement of multi-ingredient foods or real changes in intake. In terms of potassium intake, the top 12 foods identified by Cotton et al. (2004) are found within the top 14 foods on the NHANES list, and the order does not change radically. The decision was made to use the tables from Cotton et al. (2004) because they were from a peer-reviewed, published article.

Summary

Using results from the systematic review of the scientific literature and the food modeling exercises, the Committee evaluated and integrated the evidence into a set of conclusive statements and major conclusions regarding the components of the diet and physical activity that promote the health and well-being of Americans over age 2 years. These statements provide the basis for a set of straightforward guidelines for diet and physical activity.

Table C1-1. Comparison of Potassium Consumption Estimated Using Data From the 1994–1996 Continuing Survey of Food Intake by Individuals and From the 1999–2000 *National Health and Nutrition Examination Survey*

Rank	**Cotton et al. (CSFII 1994–1996)**		**NHANES 1999–2000 and SR16.1***	
	Food Group	**(%)**	**Food Group**	**(%)**
1	Milk	10.2	Milk	10.0
2	Potatoes	8.9	Potatoes	8.0
3	Coffee	6.7	Beef	7.0
4	Beef	6.2	Coffee	5.1
5	Tomatoes	6.2	Poultry	4.0
6	Orange/grapefruit juice	4.1	Orange/grapefruit juice	3.8
7	Yeast bread	3.6	Tomatoes	3.5
8	Poultry	3.3	Dried beans/lentils	2.9
9	Dried beans/lentils	2.8	Egg rolls, pizza, other mixtures	2.8
10	Bananas	2.7	Tea	2.5
11	Corn/potato chips, popcorn	2.3	Bananas	2.4
12	Tea	2.0	Yeast bread**	2.4
	Cumulative Percentage	59.0		54.3

*USDA National Nutrient Database for Standard Reference, Release 16.1.

**Followed by consommé (include soups), then corn/potato chips and popcorn.

Part D: Science Base

Section 1: Aiming To Meet Recommended Intakes of Nutrients

This section addresses five major questions related to achieving recommended intakes of nutrients and special considerations:

1. What nutrients are most likely to be consumed in amounts low enough to be of concern?
2. What dietary pattern is associated with achieving recommended nutrient intakes?
3. What factors related to diet or physical activity may help or hinder achieving recommended nutrient intakes?
4. How can the flexibility of the food pattern be increased?
5. Are special nutrient recommendations needed for certain subgroups?

The search strategies used to find the scientific evidence related to each of these questions appear in Part D, "Methodology." See Appendix G-3 for tables summarizing the findings related to Questions 3, 4, and 5.

Nutrient Intake Goals

At least 34 nutrients are needed for growth and normal body functioning. Nutrients function in many ways to build, maintain, and protect body structures and systems and to promote health. For example, some nutrients provide substrates or structure for various body tissues. Others serve as antioxidants, counteracting oxidative damage to biomolecules. Many nutrients are necessary for the production and functioning of compounds necessary for health such as hormones, enzymes, or coenzymes and for homeostasis of physiological systems. Some nutrients can be used as an energy source, and others are necessary in various stages of energy production. Prospective epidemiological studies suggest that a healthy dietary pattern—one that provides recommended intakes of nutrients—reduces the risk of some common chronic diseases, including cardiovascular disease and some cancers (see Sections D3 to D8).

One premise of the Dietary Guidelines Advisory Committee (the Committee) is that the nutrients consumed should come primarily from foods. Many people understand the importance of good nutrition but believe that a daily vitamin pill will substitute for actually eating the foods that they know are good for them. However, the more scientists learn about nutrition and the human body, the more they realize the importance of eating whole foods. For example, some studies have shown that people who eat a diet rich in beta-carotene have a lower rate of several kinds of cancer. In contrast, studies have not shown that taking beta-carotene in pill form decreases the risk of cancer (Mannisto et al., 2004; Neuhouser et al., 2003). It is possible that beta-carotene and other nutrients are most beneficial to health when they are consumed in a natural form and in combination with each other, which occurs when a person consumes foods such as fruits, vegetables (including legumes), and whole grains. These foods contain not only the well-known vitamins and minerals that are often found in vitamin pills, but also hundreds of naturally occurring substances, including carotenoids, flavonoids and isoflavones, and protease inhibitors that may protect against cancer, heart disease, and other chronic health conditions. The Institute of Medicine (IOM) report *Dietary Reference Intakes: Applications in Dietary Planning* (IOM, 2003) notes instances when fortified foods may be advantageous, including providing additional sources of certain nutrients that might otherwise be present only in low amounts in some food sources, and providing nutrients in highly bioavailable forms. Fortification can provide a food-based means for increasing intakes of particular nutrients.

Another basic premise of the Committee is that *Dietary Guidelines for Americans* should provide guidance in obtaining all the nutrients needed for growth and health. To this end, the Committee recommends that food guidance aim to achieve the most recent Recommended Dietary Allowances (RDAs), Adequate Intakes (AIs), and Acceptable Macronutrient Distribution Ranges (AMDRs) considering the individual's life stage, gender, and activity level (IOM, 1997, 1998, 2000a, 2001a, 2002, 2004). The Committee also recommends that the guidance consider the Tolerable Upper Intake Levels (ULs) (IOM, 1997, 1998, 2000a, 2001a, 2002, 2004). For convenience in

this report, the term ***Dietary Reference Intakes*** (DRIs) is used to refer to the RDAs, AIs, AMDRs, and ULs—the reference intakes that are to be considered in diet planning.

The RDA for a nutrient is "the dietary intake level that is sufficient to meet the nutrient requirement of nearly all healthy individuals in a particular life stage and gender group" (IOM, 2003, p 24). The AI is a recommended intake value used when an RDA has not been set for a nutrient. The AI "is a value based on experimentally derived levels of intake or the mean nutrient intake by a group . . . of apparently healthy people" (IOM, 2003, pp 24–25).

The IOM recommends that RDAs or AIs be used to plan diets for individuals (IOM, 2003). The planning of the food intake pattern, which was introduced in Part C, "Methodology," is an example of this application. Both the AI and RDA are intended to serve as a goal for individual intake by apparently healthy people. In general, these values are intended to cover the needs of nearly all persons in a life-stage group. Meeting the RDA provides assurance that the probability of inadequate dietary intake of the nutrient will not exceed 2 to 3 percent (IOM, 2003).

The UL is the highest level of usual intake that is likely to pose no risk of adverse health effects for nearly all individuals in the age and gender group. Since consuming intakes below the UL minimizes risk to the individual, dietary guidelines for individuals should avoid exceeding the UL (IOM, 2003).

Table D1-1, which lists nutritional goals for the U.S. Department of Agriculture's (USDA's) daily food intake pattern, shows nutrient intake goals based on the current DRIs.

Question 1: What Nutrients Are Most Likely to Be Consumed by the General Public in Amounts Low Enough to Be of Concern?

Conclusion

Reported dietary intakes of the following nutrients are low enough to be of concern:

- For adults: vitamins A, C, and E; calcium; magnesium; potassium; and fiber
- For children: vitamin E, calcium, magnesium, potassium, and fiber.

Efforts are warranted to promote increased dietary intakes of vitamin E, potassium, and fiber regardless of age; increased intakes of vitamins A and C, calcium, and magnesium by adults; and increased intakes of calcium and magnesium by children age 9 years and older. Efforts are especially warranted to improve the dietary intakes of adolescent females.

Rationale

To reach this conclusion, the Committee examined data from reports that used methods recommended by the IOM for assessing the prevalence of inadequate nutrient intakes in a population (IOM, 2001b), supplemented by data from the Centers for Disease Control and Prevention and from the Agricultural Research Service.

Methods To Identify Shortfall Nutrients

If a group has a high prevalence of inadequate dietary intake of a nutrient, that nutrient is called a ***shortfall*** nutrient. Such nutrients are consumed in amounts low enough to be of concern. Although the RDA is intended to be used in planning diets, it is not appropriate to use it for identifying the proportion of a group whose usual intake of a nutrient is less than the requirement for that nutrient (IOM, 2003). When available, the Estimated Average Requirement (EAR) is the value to be used for assessing adequacy of intake—that is, for determining the proportion of individuals whose *usual* intake is less than the EAR (IOM, 2001).

The usual intake is the long-run average intake. If intake data are available for at least 2 days, statistical methods can be used to estimate usual intake as described by Guenther et al. (1997) and by Nusser et al. (1996). Because the requirement distribution for iron is skewed, the probability approach (NRC, 1986) is the recommended method to determine the adequacy of intake of that nutrient. For nutrients for which there is an AI rather than an EAR, usual intake distributions are examined, if available, and mean intakes are compared with the AI (IOM, 2001). If mean intake is above the AI, a low prevalence of inadequate intakes is likely.

Published data using the nutrient assessment methods recommended by the IOM (2001) are available for vitamin E (Maras et al., 2004) and for intakes by school children of 13 nutrients (Suitor and Gleason, 2002). Foote and co-workers (2004) used related methods to calculate the *probability of adequacy for individuals* on a single day for 15 nutrients.

Findings Regarding Shortfall Nutrients

As shown in Table D1-2, the probability of adequate dietary intake of six nutrients was less than 60 percent for the adult men and women. These nutrients include vitamins E, A, C, and folate,[5] calcium, and magnesium. As shown in Table D1-3, mean intakes of potassium and fiber are far below the AI for all age groups. When mean intakes are below the AI for a nutrient, it cannot be assumed that the prevalence of inadequacy is low. Table D1-4 shows the results of an analysis of food intake data from the 1994–1996 Continuing Survey of Food Intake by Individuals (CSFII) for 2,692 children of school age (Suitor and Gleason, 2002). In contrast to Table D1-2, the values in this table represent *inadequacy* rather than adequacy. Nearly 80 percent of all the children had usual intakes of vitamin E that were below the EAR. The percentages of children with usual nutrient intakes below the EAR tended to increase by age group and were more pronounced for females than for males. As for adults, reported folate and magnesium intakes tended to be below the EAR for sizable percentages of children. Suitor and Gleason (2002) present data for the usual distribution of calcium intake by children. Median calcium intake was well below the AI beginning at age 9 years. Shortfalls among children were most numerous and severe for females age 14 to 18 years (Suitor and Gleason, 2002).

Although the percentages of males and females with folate intakes below the EAR are reported to be very high (see Tables D1-2 and D1-4), these values no doubt overestimate the problem (Foote et al., 2004; Suitor and Gleason, 2002). The data were collected before the Food and Drug Administration required the fortification of enriched grains with folic acid, the synthetic form of folate. In addition, the folate values are reported in milligrams of total folate rather than in dietary folate equivalents—the units in which the RDAs are given. Shikany and co-workers (2004) examined the effect of folic acid fortification on folate intake by using pre- and post-fortification folate databases to estimate folate intake of 77 women in a clinical trial involving cigarette smokers. Mean folate intake assessed with the post-fortification database was 63 percent higher than intake assessed with the prefortification database. In this small nonrepresentative study, the proportion of subjects with folate intakes below the EAR decreased ($p < 0.0001$) from 75 percent before fortification to 40 percent after fortification. This study, although limited, suggests that folate may continue to be a nutrient of concern and that attention should be given to consuming foods that are rich sources of folate.

Advance data from *National Health and Nutrition Examination Survey* (NHANES) 1999–2000 (Ervin et al., 2004), based on 1-day diet recalls, cover years when folic acid fortification of enriched grain products was in effect but folate intakes are reported in micrograms (μg) of folic acid rather than dietary folate equivalents. Although the age groups do not correspond exactly when comparing median intake with the EAR, it appears that reported median intakes by all males and children under age 12 exceeded the EAR, while intakes by females age 12 and older were still lower than the EAR. For example, median folate intakes of women age 20 to 59 years were 291 μg per day as compared to the EAR of 320 μg per day. It is not known to what extent reporting intakes in dietary folate equivalents would increase the estimated intake values. Recent nationwide data on the distribution of *usual* folate intake are not yet available to determine whether folate intake is of concern for adult women in particular or the public in general.

Nutrients That Pose Special Challenges

The Committee gives special attention to four shortfall nutrients below: vitamin E, calcium, potassium, and fiber. These four nutrients pose special challenges in developing dietary guidance to meet recommended food intakes, as explained later in this section. We address iron and vitamins B_{12}, D, and folate under Question 5, which deals with special populations. In addition, we present more detailed information about the nutrients, water, sodium, potassium, and fiber in later sections of Part D. Low intakes of vitamins A, C, and magnesium tend to reflect low intakes of fruits and vegetables. The food pattern described below shows that these nutrient requirements can be met by increasing the intake of fruits and vegetables. Tables D1-5a, D1-6a, and D1-7a list the best food sources of vitamin A, C, and magnesium per standard amount, respectively, from the Agricultural Research Service nutrient database, along with the number of calories for that standard amount. Tables D1-5b, D1-6b, and D1-7b list the major sources of these nutrients from American food consumption data.

The USDA (*Federal Register* notice, 2003) proposed a food intake pattern with the goal of meeting recommended intakes for all nutrients. The *basic food groups* used in this pattern and mentioned below are fruits, vegetables, grains, meat and beans, and milk.

[5] While the probability of adequacy for folate was found to be low, the data used were collected prior to the mandatory fortification of enriched grains with folate. See further discussion later in this section.

The proposed pattern has since been revised by USDA in collaboration with the Committee, to take into account the newly released IOM recommendations for potassium and sodium (IOM, 2004). Methods used in developing these patterns are summarized in Part C of this report. The revised food intake pattern meets nutritional recommendations for almost all nutrients, including most of the nutrients considered shortfall nutrients. Exceptions are vitamin E and potassium, as described below.

Vitamin E—As shown in Tables D1-2 and D1-4, and reported by Maras et al. (2004), vitamin E is a shortfall nutrient for nearly the entire population of U.S. adults and children. Although these data suggest widespread deficiency, there is no evidence of overt deficiency symptoms, i.e., sensory neuropathy and erythrocyte fragility, in the American population. Current intake levels likely are underestimated because of the underreporting of food intake on dietary surveys, especially related to the intake of fats and oils, and the limitations of nutrient databases with regard to the vitamin E content of foods (IOM, 2000a; Maras et al., 2004).

Most Americans do not typically consume foods that are especially rich in vitamin E on a daily basis. Table D1-8a lists the best food sources of vitamin E per standard amount from the Agricultural Research Service nutrient database along with the number of calories for that amount. Table D1-8b lists the major sources of vitamin E from American food consumption data. Although salad dressings, mayonnaise, and oils provide the greatest amount of vitamin E in American diets overall, the oil most commonly used in these products—soybean oil—is not an especially rich source of vitamin E. Oils containing higher amounts of vitamin E—sunflower, cottonseed, and safflower oils—are less commonly consumed. The same is true for nuts—almonds and hazelnuts are relatively rich in vitamin E; but peanuts and peanut butter, with lower levels of vitamin E, represent the majority of all nut consumption in the United States.

The revised USDA food intake pattern includes increases in vitamin E content over current consumption but still provides only 50 to 90 percent of the RDA for vitamin E. The food composites used in modeling the food pattern are relatively low in vitamin E content, reflecting Americans' relatively low use of foods rich in vitamin E. As the calorie level of the food pattern increases, the pattern comes closer to providing the recommended intake of vitamin E.

Calcium—Milk and milk products are rich sources of calcium. Table D1-9a lists foods that provide at least 20 percent of the adult AI for calcium in standard amounts along with the number of calories provided by that serving size. Milk and milk products also are the major sources of calcium in U.S. diets (Table D1-9b), but calcium intake falls considerably short of the AI for most age groups beginning at age 9 years, especially for females. The revised USDA food pattern specifies 2 or 3 cups per day from the milk group, based on the calorie level of the pattern,[6] and meets the goals for calcium intake. The rationale for Question 4 below includes several tables that address ways to achieve recommended calcium intake. Part D, Section 6, "Selected Food Groups," addresses relationships of milk products with health.

Potassium—Potassium intake falls short of the AI for all age groups examined, but sources of potassium come from all the basic food groups. Table D1-10a lists the potassium content and calories for standard amounts of foods ranked by potassium content. For calorie levels at or above 1,600 kcal per day, the revised USDA food pattern provides more than 76 percent of the AI for potassium. For calorie levels less than 1,600 kcal per day, only 64 to 75 percent of the AIs would be met. As was the case for vitamin E, some of the food composites used in modeling the food pattern are relatively low in potassium content, reflecting Americans' relatively low use of some of the better potassium sources (see Table D1-10b for a list of major sources of potassium in American diets). The rationale for Question 2 below describes how this problem was addressed.

Fiber—As for potassium, fiber intakes fall short of the AIs for all age groups examined. Table D1-11a lists the fiber content and calories for standard amounts of foods ranked by fiber content. As can be seen in Table D1-11b, the major source of fiber in the U.S. diet is yeast bread; however, white bread, which is the most common form of yeast bread, does not appear in the list of foods that are among the best fiber sources. The large amount of white yeast breads consumed (as bread, rolls, buns, and pizza crust) causes this food to be a major fiber contributor to American diets. However, legumes, many vegetables and fruits, and

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[6] In the food pattern with 1,000, 1,200, and 1,400 calories, which are targeted to children under age 9, 2 cups from the milk group are recommended. In the food pattern with 1,600 calories and above, 3 cups from the milk group are recommended.

whole grains are far better dietary fiber sources for a standard amount.

Table D1-12 identifies the functions of the shortfall nutrients that are listed above. Increasing one's intake of each of these nutrients to achieve recommended nutrient intakes can help promote health.

Question 2: What Dietary Pattern is Associated with Achieving Recommended Nutrient Intakes?

Conclusion

Two major aspects of the USDA dietary pattern contribute to meeting nutrient intake recommendations:

1. Consumption of foods from each of the basic food groups:
    - fruits
    - vegetables
    - grains
    - milk, yogurt, and cheese
    - meat, poultry, fish, dry beans, eggs, and nuts[7]
2. Consumption of a variety of food commodities within each of those food groups—because higher energy intake is strongly associated with greater variety and higher nutrient intake, attention also should be given to food group choices that maintain appropriate energy balance.

Rationale

This conclusion is supported by food pattern modeling conducted by USDA's Center for Nutrition Policy and Promotion (CNPP) and by one published study (Foote et al., 2004) that links survey data on food intake with data on nutrient intakes. It also is supported by information on nutrients provided by the basic food groups and their subgroups.

Food Pattern Modeling

The USDA method of food pattern modeling, which is described briefly in Part C, "Methodology," and in detail in "Notice of Availability of Proposed Food Guide Pyramid Daily Food Intake Patterns and Technical Support Data" (*Federal Register* notice, 2003), is a well-documented approach for developing the food pattern (Welsh et al., 1993). The method is intended to develop the food pattern that meets the DRIs and that is as realistic and practical as possible (*Federal Register* notice, 2003). The food intake pattern was first developed using this method in the 1980s, and became the scientific basis for the Food Guide Pyramid. In 2003, a new pattern (developed using this same method) was proposed and submitted for public comment by USDA. Since then, USDA has slightly revised the proposed pattern to account for recent recommendations for potassium and sodium (IOM, 2004) and provided the Committee with the revised pattern. USDA states that it will use this report of the 2005 Dietary Guidelines Advisory Committee to finalize a new food intake pattern and will then develop graphic and educational materials for the public based on this pattern.

In developing the new daily food pattern, the nutrient content of the preliminary pattern was compared to the new nutritional goals. If the goals were not met at a given calorie level, amounts from food groups or subgroups that were higher in the nutrients in question were increased, and corresponding changes were made in other groups to maintain total calories at the goal level. The adjustments were made in an iterative manner, to bring the pattern closer to its nutritional goals.

Most of the nutritional goals for the USDA food intake pattern, as identified in the *Federal Register* notice, were met by making relatively modest changes from the pattern used in the original Pyramid (Welsh et al., 1993). (See Appendix G-2 for a table of food patterns from the original Pyramid.) Changes included the following:

- Increasing the number of calorie levels from 3 (1,600, 2,200, 2,800) to 12 (every 200 calories from 1,000 to 3,200).
- Separation of discretionary fats into solid fats and oils and soft margarines, and a shift in the proportions recommended to 40 percent solid fats, 60 percent oils—The original Pyramid pattern did not distinguish among types of fats, and the proportions were therefore the estimated intake proportions of 58 percent solid fats, 42 percent oils.
- Increasing the amounts of vegetables for some calorie levels—To meet nutritional goals, the

[7] Some patterns designed to meet nutrient intake recommendations divide this group into two groups: (1) meat, poultry, and fish, and (2) seeds, dry peas and beans, and nuts.

overall amounts of vegetables recommended were increased for several calorie levels.
- Change in the relative amounts of vegetable subgroups—The nutrient profiles of dark green vegetables and legumes were relatively high in the nutrients needed to meet unmet nutrient goals. Therefore, amounts of these vegetables were preferentially increased and amounts of the remaining vegetable subgroups (starchy, orange, and other vegetables) were held constant or decreased.
- Increase in the amount of whole grains to one-half of the total amount in every pattern—Enriched grains were proportionately decreased. At least 3 oz. of whole grains are provided for the calorie levels equal to and above 1600 kcal per day.

The Committee examined these data and noted the concern identified by USDA that the pattern provides only 50 to 75 percent of the RDA for vitamin E at all except the highest calorie levels. In contrast, the pattern provides well over 100 percent of the RDA for many of the nutrients.

The Committee also noted that the nutrient profiles use the lowest fat forms of each food in the food group and/or a form free of added sugars. Thus, the foods that make up the composite could be described as a nutrient-dense version of the foods. Examples include nonfat milk, chicken without the skin, and ground beef with no more than 5 percent fat. Although this approach allows food pattern recommendations to provide individuals a way to meet their nutrient needs while avoiding the overconsumption of calories and of food components such as saturated fats, the Committee recognized that this key aspect of the nutrient profiles could be overlooked easily and merits emphasis in nutrition education efforts.

In February 2004, the IOM released the report *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate* (IOM, 2004). This report included new AIs for potassium—values that were more than two times as high as the potassium goals used in developing the food pattern published in the *Federal Register* notice. Consequently, at the Committee's request, USDA made adjustments in the food intake pattern so that it would provide higher percentages of the AI for potassium. The adjustments required increasing milk or other milk products to 3 cups or the equivalent, increasing vegetables by 0.5 cups and increasing fruits by 0.5 cups, per day. To compensate for the calories provided by the increases in these three groups, the amounts of grains in the pattern were decreased by about 1 ounce equivalent, and added sugars and solid fats were decreased for some age and/or sex groups.

Tables D1-13 and D1-14 show the revised USDA food pattern that incorporates the new standards for potassium.[8] The nutritional goals for this pattern, shown in Table D1-1, were based on the current Dietary Reference Intakes (IOM, 1997, 1998, 2000a, 2001a, 2002, 2004). The nutrient content that was assigned to a standard amount of food from each food group and subgroup appears in Table D1-15. The values in Table D1-15 were used in combination with the daily intake amount for each food group or subgroup to estimate the amounts of nutrients provided by the food intake pattern (Table D1-16).

The revised food intake pattern differs in important ways from food intake patterns that reflect usual food consumption by Americans. In particular, for many age groups and energy levels the pattern includes:

- **more** green vegetables, orange vegetables, legumes, fruits, whole grains, and milk
- **less** enriched grains, total fats (especially solid fats), and added sugars

As shown in Table D1-13, the food pattern includes suggested amounts to eat from each of the basic food groups: fruits, vegetables, grains, meat and beans (which includes meat, poultry, fish, dry beans, eggs, and nuts), and milk (which includes nonfat milk, yogurt, and cheese).

The food pattern also shows suggested amounts of oils to consume, because oils are major contributors of essential fatty acids and vitamin E. In addition, the pattern lists amounts of *discretionary calories* that can be accommodated within each calorie level. Table D1-14 provides more detail about discretionary calories and lists one way these calories can be split—between solid fats and added sugars. These solid fats and added sugars may be contained in selections made from the basic food groups. For example, the fats in low-fat or whole milk and in higher-fat meat products are counted as solid fats; and the sugars that are added in the processing of sweetened cereals, fruits canned in syrup, or cookies are counted as added sugars. Similarly, one

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[8] USDA has informed the Dietary Guidelines Advisory Committee that the *final* nutritional goals and food intake pattern will take into account all nutritional recommendations from this Committee.

needs to count solid fats (e.g., butter) or various sugars (e.g., syrup) that are added to foods. Discretionary calories may also be used to increase the amounts of nutrient-dense choices from any food group, such as increased amounts of fruits or vegetables. (See Section D-3, "Discretionary Calories," for further information.)

Clearly, examination of Table D1-16 reveals that following the proposed pattern for one's calorie level would promote reaching recommended intakes of almost all nutrients. The RDA or AI is reached or exceeded for nearly all nutrients at most calorie levels. Vitamin E remains the leading exception. By making careful selections from Table D1-8a, the vitamin E recommendations could be achieved while limiting total fat intake to 20 to 35 percent of energy. Potassium is another exception: at 2,000 calories or below, less than 90 percent of the AI for potassium is provided by the revised food pattern. Selecting fruits and vegetables that have relatively high potassium content helps to meet the AI for potassium. A number of these foods are listed in Table D1-10a.

Studies Linking Food Intake with Recommended Nutrient Intake

The only published study (Foote et al., 2004) that links food intake with current recommended nutrient intakes (IOM, 1997, 1998, 2000a, 2001a, 2002, 2004) used data on adults in the CSFII 1994–1996. Foote and colleagues (2004) found high correlations among energy intake, intakes from the five food groups, and the variety of different food commodities consumed from the basic food groups. Food commodities represent different food types, such as beef, oranges, wheat, and milk. Different preparations of these foods would be counted as the same basic food commodity. For example, for variety within the grain group, rice, white bread, and oatmeal would count as different commodities, but white bread, pancakes, and English muffins would not be considered different commodities. The combination of energy, intakes from the five food groups, and dietary variety was a strong predictor of the mean probability of adequacy ($R^2 = .73$ for men and .70 for women). Dietary variety within the milk and grain groups was more strongly correlated with improved nutrient adequacy than was variety within the remaining food groups. However, this analysis does not include data on potassium or fiber intake.

A number of studies have been conducted to determine the extent to which Americans have followed the guidance provided by the Food Guide Pyramid and how this relates to their nutrient intake. For example, three studies compare food intakes from national surveys with the recommended number of servings of food from the original Pyramid food intake pattern (Cleveland et al., 2000; Krebs-Smith et al., 1997; Munoz et al., 1997). In most cases, the revised food intake pattern in Table D1-13 specifies more servings of fruits, vegetables, and whole grains than does the 1992 Pyramid food pattern.

Cleveland et al. (2000) analyzed food and nutrient intake by adults, using data from CSFII 1994–1996 that focused on whole grain intake. These investigators found that consumers of whole grains had significantly better vitamin and mineral profiles than nonconsumers. Whole grain consumers also were more likely to meet Pyramid recommendations for the grain, fruit, and milk groups. Only 17 percent of the population consumed at least two servings of whole grains per day.

Two early studies analyzed food and nutrient intake data from CSFII 1989–1991 using Pyramid recommendations based on energy. Krebs-Smith et al. (1997) reported that adults who met Pyramid recommendations for all food groups had mean vitamin and mineral intakes that exceeded 100 percent of the 1989 RDA (NRC, 1989), mean daily fiber intake of 22 g, and fat intake at the then recommended level of 30 percent of calories. In contrast, at least one nutrient intake shortfall was found for food group patterns that did not meet one or more of the Pyramid food group recommendations. Munoz et al. (1997) found comparable micronutrient results for children who met the Pyramid recommendations, and they reported a mean daily fiber intake of 19 g. The children's fat intake averaged 35 percent of calories. In both studies, fewer than 5 percent of the population met all Pyramid recommendations.

Nutrients Provided by the Basic Food Groups and Their Subgroups

Basic Food Groups in the USDA Food Intake Pattern—Table D1-17 summarizes the nutrient contributions of each of the basic food groups and of subgroups for vegetables and grains. To prepare the table, the percent contribution from each food group to the total intake of a nutrient was calculated at each calorie level and then averaged across all calorie levels. The method used to develop this table appears in Appendix G-2 along with more detailed results. Since the amount of nutrients provided by each food group is estimated based on foods commonly consumed in the United States, the nutrient contributions of food groups to an individual's diet could differ somewhat, depending on the foods selected from each group. The

"Major Contribution" column identifies any nutrient provided by the food group in an amount greater than that provided by any of the other food groups.

Results of the analysis include the following:

- Each food group is the major contributor of at least one nutrient. In addition, each group makes substantial contributions of many other nutrients. Each vegetable subgroup provides at least one nutrient in an amount exceeding 10 percent of the total, even though the amount of food specified for each vegetable subgroup is relatively small.
- For a few nutrients, the food group that is the major contributor of a nutrient shifts from calorie level to calorie level within the USDA food pattern. For example, for potassium, the milk group is the major contributor at most calorie levels, but at higher calorie levels there are more fruit servings, thereby making the fruit group the major contributor of potassium.
- For a few nutrients, a single food group provides a majority of the overall amount in the food pattern. This is true for vitamin C, for which the fruit group provides about 67 percent of the total; calcium, for which the milk group provides about 67 percent; and linoleic and α-linolenic acids, for which oils and soft margarines provide about 59 percent and 53 percent, respectively. For all other nutrients, no single food group provides more than half of the total amount of the nutrient provided by the food pattern.
- Each food group provides a wide array of nutrients in substantial amounts, emphasizing the importance of including all food groups in the daily diet.

Health Effects of Dietary Patterns Similar to the USDA Food Intake Pattern

The revised USDA food intake pattern results from a modeling process that integrated nutrient recommendations from the IOM, as described above. Because the process did not include the preparation of actual menus, it is appropriate to confirm that Western style menus can be constructed that meet the new IOM's nutrient recommendations. It also is useful to document the health effects of dietary patterns similar to the revised USDA food intake pattern since one goal of using the pattern is to help reduce the risk of chronic disease. To this end, results from the Dietary Approaches to Stop Hypertension (DASH) trials (Appel et al., 1997; Sacks et al., 2001) are informative.

The first DASH trial was a randomized feeding study that tested the effects of three distinct dietary patterns on blood pressure. Participants were randomized to (1) a control diet, (2) a fruits and vegetables diet, or (3) a diet now termed the DASH diet. The control diet had a nutrient composition that is typical of that consumed by many Americans. Its potassium, magnesium, and calcium levels were relatively low, and its macronutrient profile and fiber content corresponded to average U.S. consumption. The fruits and vegetables diet was rich in potassium, magnesium, and fiber but otherwise similar to the control diet. The DASH diet emphasized fruits, vegetables, and low-fat dairy products; included whole grains, poultry, fish, and nuts; and was reduced in red meat, sweets, and beverages with added sugars. The DASH diet was rich in potassium, magnesium, calcium, and fiber, and was reduced in total fat, saturated fat, and cholesterol; it also was slightly increased in protein. A 7-day menu cycle at each of 4 calorie levels (1,600; 2,100; 2,600; and 3,100) was prepared using commonly available foods (Karanja et al., 1999). As displayed in Table D1-18, the nutrient profile of the DASH diet is nearly identical to that of USDA revised food pattern.

Among all participants, the DASH diet significantly lowered mean systolic blood pressure by 5.5 mmHg and mean diastolic blood pressure by 3.0 mmHg (net of control). The fruits and vegetables diet also significantly reduced blood pressure but to a lesser extent: it had about half of the effect of the DASH diet. In subgroup analyses, the DASH diet significantly lowered blood pressure in all major subgroups (men, women, blacks, non-blacks, hypertensives and non-hypertensives). In blacks, blood pressure reductions (systolic blood pressure/diastolic blood pressure) from the DASH diet (6.9/3.7 mmHg) were significantly greater than corresponding reductions in white participants (3.3/2.4 mmHg). The reductions in hypertensive individuals (11.6/5.3 mmHg) were striking and have obvious clinical relevance. In non-hypertensive individuals, corresponding net blood pressure reductions were 3.5/2.2 mmHg. Such blood pressure reductions, while smaller in magnitude, nonetheless have substantial public health relevance. In the DASH-Sodium trial, the DASH diet also lowered blood pressure at each of three sodium levels. In addition to blood pressure reduction, the DASH diet had beneficial effects on blood lipids (Harsha et al., 2004; Obarzanek et al., 2001) and on several biomarkers, including homocysteine (Appel et al., 2000) and markers of oxidative stress (Miller et al., 1998) and bone turnover (Lin et al., 2003).

It has been estimated that a population-wide reduction in blood pressure of the magnitude observed in DASH could reduce stroke incidence by 27 percent and coronary heart disease (CHD) by 15 percent (Appel et al. 1997). Further reduction in CHD risk might be anticipated from changes in lipids and perhaps homocysteine. In observational epidemiological studies, dietary patterns similar to the DASH diet have been associated with a reduced risk of ischemic heart disease in men (Hu et al., 2000) and women (Fung et al., 2001).

Part D, Section 6, "Selected Food Groups," addresses relationships of the following food groups to health: fruits, vegetables, whole grains, and milk products.

Question 3: What Factors Related to Diet or Physical Activity May Help or Hinder Achieving Recommended Nutrient Intakes?

Conclusion

A sedentary lifestyle limits the amount of calories needed to maintain one's weight. Careful food selection is needed to meet recommended nutrient intakes within this calorie limit. Diets that include foods with a high nutrient content relative to calories are helpful in achieving recommended nutrient intakes without excess calories. Diets that include a large proportion of foods or beverages that are high in calories but low in nutrients are unlikely to meet recommended intakes for micronutrients and fiber, especially for sedentary individuals.

Rationale

This conclusion is based on a review of data on the effects of physical activity on the total energy requirement from a combination of 26 clinical trials and review articles related to nutrient density and dietary diversity (see Appendix G-3), 12 of which are cited within the body of the text. It also is based on studies of the effects of intake of added sugars on nutrient intake, which are covered in detail under Question 4 in Section 5, "Carbohydrates."

Physical Activity

The higher one's physical activity level, the higher the energy requirement, and the easier it is to plan a food intake pattern that meets recommended nutrient intakes. This is apparent when one examines the percentages of recommended nutrient intakes (see Table D1-16) that are provided by the revised USDA food intake pattern. The food intake pattern at higher energy (calorie) levels results in intakes that are less likely to be below recommended nutrient intakes and more likely to exceed them. In addition, it allows more leeway for foods that contain added sugars and solid fats. As reported by Foote et al. (2004), energy intake is the strongest predictor of the mean probability of adequacy. Increasing one's physical activity level is a healthy way to increase one's energy requirement. (See Section 2, "Energy," for additional information about physical activity.)

Nutrient Density

Nutrient-dense foods are those that provide substantial amounts of vitamins and minerals and relatively fewer calories. Foods that are low in nutrient density are foods that supply calories but relatively small amounts of micronutrients (sometimes none at all). In contrast, energy-dense, nutrient-poor foods supply relatively small amounts of vitamins and minerals with many calories. A number of epidemiological studies using data obtained from national surveys suggest that energy-dense, nutrient-poor foods may displace nutrient-dense foods, potentially reducing the consumption of foods from the five foods groups to lower levels than recommended and limiting one's ability to achieve recommended nutrient intakes (Kant, 2000, 2003; Kant and Schatzkin, 1994). Increased intake of energy-dense, nutrient-poor foods was reported to result in increased total daily energy intake and smaller proportions of the population meeting the RDA for various nutrients. Respondents consuming a high proportion of energy-dense, nutrient-poor foods were more likely to report either no servings or less than the recommended number of servings of foods from the major food groups (Kant and Schatzkin, 1994). The strongest independent negative predictor of the reported number of foods of low nutrient density was the amount of nutrient-dense foods from the five major food groups (Kant and Graubard, 2003).

Dietary diversity among and within food groups was not related to total energy, fat, sugar, sodium, or cholesterol intake (Krebs-Smith et al., 1987), but individuals who consumed the greatest variety of foods (among the food groups, not within the food groups) had the most adequate nutrient intake (Kant et al., 1991).

Individuals consumed more total food when offered several different foods than when variety was more limited (Bellisle and Magnen, 1981; Pliner et al., 1980;

Rolls et al., 1981a, 1981b, 1982; Spiegel and Stellar, 1990). In contrast, increased amounts of low-energy vegetables, prompted by high variety, have resulted in decreased energy intake and body fatness (McCory et al., 1999). The long-term effects of dietary variety on food intake and body weight are unknown.

Choosing foods that are rich sources of nutrients in short supply can be an effective way to put the concept of nutrient density into action. Using the food pattern in Table D1-13 that is appropriate for one's energy needs is one way to achieve a diet that meets recommended nutrient intakes.

Effects of Added Sugars on Vitamin and Mineral Intake

Added sugars are defined as sugars and syrups that are eaten separately at the table or added to foods during processing or preparation. As presented in detail in Section 5, "Carbohydrates," 19 papers show a decreased intake of at least 1 micronutrient with higher levels of added sugar intake. That section also provides evidence that small amounts of added sugars may have a beneficial effect on intake of vitamins and minerals, probably by improving the palatability of foods and beverages that might otherwise not be consumed.

Question 4: How Can the Flexibility of Food Patterns be Increased?

Conclusion

By careful planning that considers the relative nutrient content of different foods, substitutions can be made to a food intake pattern to achieve recommended nutrient intakes.

Rationale

The Committee used empirical methods to identify ways to build flexibility into its recommendations for food guidance. In particular, the Committee asked USDA to use food pattern modeling or other nutrient analysis methods to identify ways to increase the flexibility of the proposed USDA food pattern while continuing to meet the nutritional goals. See Appendix G-2 for information about these analyses. Specific requests included identifying substitutions for refined grain products, legumes, and milk and milk products; comparing the nutrient contributions of fruits with fruit juices; and developing a lacto-ovo-vegetarian food pattern that met nutrient goals.

Legumes and Refined Grains

For individuals who choose not to eat legumes or refined grains, USDA staff prepared short lists of specific amounts of foods that could be substituted without substantially changing the nutrients or calories provided by a food pattern. For example, specified amounts of whole grains, dark green vegetables, and other vegetables could be substituted for a serving of legumes. More information appears in Part E and in Appendix G-2.

Milk and Milk Products

The milk group provides more than 70 percent of the calcium consumed by Americans. Other choices of dietary calcium are available (see Table D1-9a and Table D1-19) for those who choose not to consume the recommended quantities of milk products. Both calcium content and bioavailability should be considered when selecting dietary sources of calcium. Some plant foods have calcium that is well absorbed, but the large quantity of plant foods that would be needed to provide as much calcium as in a glass of milk may be unachievable for many. Many other calcium-fortified foods are available, but the percentage of calcium that can be absorbed is unavailable for many of them.

For individuals who avoid milk because of its lactose content, the most feasible way to obtain all the nutrients provided by dairy is to substitute lactose-reduced or low-lactose milk products (see Part E).

The inclusion of milk products in the proposed food pattern contributes important amounts of calcium, potassium, magnesium, and vitamin A (see Table D1-20). Moreover, low calcium intakes have been associated with low intakes of magnesium, riboflavin, vitamin B_6, vitamin B_{12}, and thiamin (Barger-Lux et al., 1992). Increased milk product intake was associated with increased intake of calcium, magnesium, potassium, zinc, iron, vitamin A, riboflavin, and folate by Americans over the age of 2 (Weinberg et al., 2004). Without milk products in the revised USDA food intake pattern, calcium intakes range from 321 to 965 mg per day less than recommended intakes (see Table D1-21). These calcium values are the amounts provided by 1.1 to 3.2 glasses of milk. To meet recommended nutrient intakes, the food intake pattern that excludes milk would need to include a much larger amount of calcium-containing green vegetables and legumes than typically consumed by Americans.

Nondairy alternatives for calcium such as calcium-fortified orange juice or calcium-fortified soymilk

products are listed in Table D1-19. This table considers only calcium and not the other nutrients provided by milk.

Fruits

The Committee also asked USDA to examine appropriate partitioning of the fruit group into fruit and juices. The question being addressed was, "How would guidance on the proportion of juice supplied by fruit juice affect the meeting of nutritional goals?" This question stemmed from a recent recommendation of the American Academy of Pediatrics (AAP) to limit fruit juice to no more than 4 to 6 ounces per day for children age 1 to 6 years, and to no more than 8 to 12 ounces per day for children age 7 to 18 years (AAP, 2001). Based on the fruit group analysis, the recommendation is to consume no more than one-third of the total recommended fruit group intake amount from fruit juice and the remainder from whole fruit (fresh, frozen, canned, dried). Increasing the proportion of fruit that is eaten in the form of whole fruit rather than juice is desirable to increase fiber intake, but it calls for more attention to consuming foods that are high in potassium. The fruit juices most commonly consumed by older children and adults provide more vitamin C, folate, and potassium in portions usually consumed than do the commonly eaten fruits. The recommended intake of fruits and juices achieve an optimal balance.

The Lacto-Ovo Vegetarian Food Pattern

The Committee also asked USDA to examine how substituting nuts, seeds, and legumes for meat, poultry, and fish in the food pattern would affect the nutrient profile of the food group. The amount of eggs in the pattern was held constant. Although the nutrient profile of the egg, nut, seed, and legume group differed in some ways from the original "meat and beans group," it still provided for a food pattern that met recommended nutrient intakes. The lacto-ovo-vegetarian pattern was higher in vitamin E, fiber, and folate than the original pattern. It was lower, although still at or above recommendations, in protein, many B vitamins, and zinc; and it was lower in cholesterol.

Nuts, Seeds, and Legumes in the Food Pattern

The Subcommittee considered the possibility of recommending that nuts, seeds, and legumes become a separate food group because they are rich sources of trace nutrients and rich in diverse phytochemicals. Some nuts are also rich in vitamin E, and nuts may promote satiety. However, the most commonly consumed types of nuts (i.e., peanuts) are not especially high in vitamin E, and the consumption of large amounts of nuts could lead to an excess intake of calories. Rather than creating a separate food group for nuts and seeds, the Committee decided to recommend selecting choices from a list of foods rich in vitamin E as a means to help individuals increase their intakes of that vitamin. It was suggested that modifying the USDA food model system to include a food group rich in vitamin E, such as nuts or seeds, could provide a food pattern that meets the RDA for vitamin E (King et al., 1978). The lacto-ovo vegetarian pattern developed by USDA includes what is essentially a nut/seed/legume group that includes eggs, to replace all meat, poultry, and fish servings. The vitamin E in this pattern is 70 percent RDA at 1,800 kcal and 84 percent at 2,200 kcal. It does not reach 100 percent RDA until 2,800 calories.

Question 5: Are Special Nutrient Recommendations Needed for Certain Subgroups?

Conclusion

Special nutrient recommendations are warranted for the following subgroups and nutrients:

- Adolescent females and women of childbearing age—iron and folic acid
- Persons over age 50—vitamin B_{12}
- The elderly, persons with dark skin, and persons exposed to insufficient UVB radiation—vitamin D

A conclusion and rationale specific to each group and nutrient follows.

Women and Iron Conclusion

Substantial numbers of adolescent females and women of childbearing age have laboratory evidence of iron deficiency. Efforts are warranted to increase the dietary intake of iron-rich foods and of enhancers of iron absorption by these groups.

Women and Iron Rationale

Laboratory data from the *Third National Health and Nutrition Examination Survey* (NHANES III)(1988–1994) indicate that iron deficiency (defined as having an abnormal value for at least two of three laboratory tests of iron status) affects 7.8 million adolescent females and women of childbearing age (age 12 to 49 years) (Looker et al., 1997). That is, 9 to 11 percent of nonpregnant women of childbearing age were iron deficient, and 2 to 5 percent of the women had iron-deficiency anemia. These findings suggest the need to

encourage this age group to increase dietary intake of iron-rich foods and of enhancers of iron absorption (meat and vitamin C). A list of sources of iron is provided in Table D1-22a and D1-22b.

Women and Folic Acid Conclusion
Since folic acid reduces the risk of the neural tube defects (NTD), called spina bifida and anencephaly, daily intake of 400 μg of synthetic folic acid (from supplements or fortified food) is recommended for women who are capable of becoming pregnant and those in the first trimester of pregnancy.

Women and Folic Acid Rationale
The folic acid conclusion is based on the extensive review conducted by the IOM (IOM, 1998) and review of the two available reports on effects of folic acid fortification of enriched grain products. Based on its review of 7 population-based studies, 1 controlled metabolic study, plus 1 additional piece of evidence, the IOM concluded, "the recommendation for women capable of becoming pregnant is to take 400 μg of folate from fortified foods and/or a supplement as well as food folate from a varied diet. It is not known whether the same level of protection could be achieved by using food that is naturally rich in folate" (IOM, 1998, p 12).

Since the relatively new folic acid fortification program to reduce the risk of NTDs could influence the need for obtaining folic acid from supplements, the Committee reviewed the two available reports on the effects of the fortification program. Evans et al. (2004) report that, post fortification, the percentage of high maternal serum alpha-fetoprotein values obtained during midtrimester of pregnancy decreased by 32 percent. The Centers for Disease Control and Prevention (CDC, 2004b) report that the incidence of spina bifida and anencephaly decreased by 26 percent between the pre- and post-fortification periods (1995–1996 and 1999–2000), suggesting that the fortification of enriched grains has helped reduce risk. They note that the observed decrease in NTD-affected pregnancies is less than the estimate that was based on data from research trials.

Persons Over Age 50 and Vitamin B_{12} Conclusion
A substantial proportion of individuals over age 50 may have reduced ability to absorb naturally occurring vitamin B_{12} but not the crystalline form. Thus, all individuals over the age of 50 should be encouraged to meet their RDA for vitamin B_{12} by eating foods fortified with vitamin B_{12} such as fortified cereals, or by taking the crystalline form of vitamin B_{12} supplements.

Persons Over Age 50 and Vitamin B_{12} Rationale
This conclusion was supported by evidence from a systematic review conducted for the IOM (IOM, 1998) and by recent laboratory studies to screen for functional vitamin B_{12} status, as summarized below, resulting in 11 studies.

According to the NHANES in 1999–2000 for the U.S. population, mean daily vitamin B_{12} intake was above the RDA for all ages and both sexes, and ranged from 2.9 to 5.1 µg (CDC, 2004a). For people age 40 to 59 and age 60 and above, the mean and standard deviation of vitamin B_{12} intake were 5.1±0.37 and 4.5±0.25 µg per day, respectively. Data are not available regarding the amount of crystalline vitamin B_{12} consumed from fortified foods and supplements by people over age 50.

Based on a systematic, extensive review of the literature, the IOM (1998) set the RDA for vitamin B_{12} at 2.4 µg per day. However, since 10 to 30 percent of the older population may be unable to absorb naturally occurring vitamin B_{12}, the IOM advised that persons age 50 and older should meet their RDA mainly by consuming foods fortified with vitamin B_{12} or by taking vitamin B_{12}-containing supplements. This RDA was based on the amount needed to maintain the hematological status, as well as the normal serum vitamin B_{12} level. Neurological manifestation of vitamin B_{12} deficiency was not used to establish vitamin B_{12} status since it occurs at a later depletion stage than does the hematological status. Furthermore, the progression of neurological manifestation is variable, generally gradual, and currently not amenable for easy quantification.

This conclusion was further supported by recent studies utilizing serum radio-immunoassays of vitamin B_{12}, combined with serum total homocysteine (tHcy) and methylmalonic acid (MMA) values, to screen for functional vitamin B_{12} status. A low serum vitamin B_{12} value (< 300 pg/mL), high-serum MMA value (> 0.4 µmol/L), and tHcy greater than 15.0 µmol/L would suggest vitamin B_{12} deficiency. Using results from these three laboratory tests, Clarke and colleagues (2004) reported the prevalence rate of vitamin B_{12} deficiency to be 1 in 20 among people age 65 to 74, and 1 in 10 among people age 75 and older. Additionally, various clinical trials (McKay et al., 2000), either among free-living or institutionalized

elderly, demonstrated that either oral vitamin B_{12} supplements alone or multivitamin/mineral supplements could improve vitamin B_{12} status.

A screening procedure using serum radioimmunoassay of vitamin B_{12} combined with serum tHcy and MMA has been recommended for all individuals over age 65 to detect vitamin B_{12} deficiency (Dharmarajan et al., 2003; Klee, 2000).

Special Groups and Vitamin D Conclusion

The elderly, persons with dark skin, and persons exposed to insufficient UVB radiation are at risk of being unable to maintain vitamin D status. Persons in these high-risk groups may need substantially more than the 1997 AI for vitamin D from vitamin D-fortified foods and/or vitamin D supplements.

Vitamin D Rationale

The relationship of vitamin D to health was evaluated from a systematic review of the scientific literature, which produced 28 studies and 14 reviews—largely articles that were unavailable when the IOM conducted its review on which the AIs for vitamin D were based (IOM, 1997). Adequate vitamin D status, which depends on dietary intake and cutaneous synthesis, is important for optimal calcium absorption, and it can reduce the risk for bone loss.

The criterion used by the IOM for setting the AI was the normal concentration of serum 25-hydroxyvitamin D concentration, an indicator of vitamin D status. In the absence of consensus for optimal vitamin D status based on functional indicators, the IOM panel identified normal ranges for serum 25-hydroxyvitamin D. The normal range for various populations is broad with means of serum 25-hydroxyvitamin D ranging from 25 to 137.5 nmol/L. Newer information on the relationship of serum 25-hydroxyvitamin D to health, the relationship of vitamin D intake to serum 25-hydroxyvitamin D concentration, vitamin D status of the U.S. population, and safety of vitamin D intakes is summarized in a supplement of a National Institutes of Health conference held in October 2003 (NIH, 2004). Two functionally relevant measures indicate that optimal serum 25-hydroxyvitamin D may be as high as 80 nmol/L. Among postmenopausal women who lived in Omaha, Nebraska, and who were supplemented with vitamin D, calcium absorption efficiency increased with increasing serum 25-hydroxyvitamin D values up to 80 nmol/L (Heaney et al., 2003b). Serum parathyroid hormone, which stimulates bone resorption, decreases with increasing serum 25-hydroxyvitamin D values up to 80 nmol/L (Chapuy et al., 1997; Thomas et al., 1998). Serum 25-hydroxyvitamin D values are below 80 nmol/L for much of the population (Looker et al., 2002; see Table D1-23).

The elderly and individuals with dark skin are at a greater risk of low serum 25-hydroxyvitamin D concentrations (Holick 1985; Holick et al., 1989; Looker et al., 2002). Also at risk are those exposed to insufficient UVB radiation for the cutaneous production of vitamin D, e.g., housebound individuals. Serum 25-hydroxyvitamin D values increase with increasing oral vitamin D intake in both young and older subjects (Vieth et al., 2003). Further data are needed to determine if a serum 25-hydroxyvitamin D concentration of 80 nmol/L is sufficient to increase the efficiency of calcium absorption or to reduce PTH levels in the populations at risk.

For individuals within the high-risk groups, substantially higher daily intakes of vitamin D, i.e., 25 μg or 1000 IU of vitamin D, have been recommended to reach and maintain serum 25-hydroxyvitamin D values at 80 nmol/L (Heaney and Weaver, 2003; Holick, 2004). Applying the slope (0.7 mmol/L/microgram vitamin D) from the regression between vitamin D intake and change in serum 25-hydroxyvitamin D derived from a dose response study in men (Heaney et al., 2003b) to the mean serum 25-hydroxyvitamin D concentrations in the U.S. population shown in Table D1-23, one can estimate the additional vitamin D intake required to achieve and maintain a target vitamin D status. For example, women over age 80 with mean serum 25-hydroxyvitamin D values of 59.6 nmol/L might need to increase their vitamin D intakes by 29 μg or 1,166 IU per day to achieve serum values of 80 nmol/L. Mean current consumption of vitamin D in females over age 71 participating in NHANES III was only 4.5 μg or 180 IU of vitamin D (Moore et al., 2004), an amount considerably below the 1997 AI of 600 IU. Dark skinned subgroups have lower vitamin D status than comparable fair-skinned subgroups, but the optimal vitamin D status and the ability of vitamin D intakes to increase serum 25-hydroxyvitamin D concentrations in various subgroups are not known.

A recent estimate of the vitamin D intakes of Americans surveyed in either NHANES III, 1988–1994, or the CSFII 1994–1996, 1998, showed that the average reported intakes from food and supplements by all age and gender groups were below the 1997 IOM AI for vitamin D (Moore et al., 2004). Less than 10 percent of older adults (age 51 to 70) and only about 2

percent of the elderly (older than age 70) met the AI from food sources alone. Less than one third of the adolescent and adult women met the AI.

Fatty fish is the primary natural food source of vitamin D. Other good sources are all foods that have been vitamin D fortified: milk and some brands of margarine, ready-to-eat breakfast cereal, enriched rice and pasta, and fruit juices and drinks. Different kinds of vitamin D-fortified foods differ in the amounts of vitamin D they contain (Table D1-24). Vitamin D intakes of approximately 1,000 IU per day can be achieved by consuming 3 cups of vitamin D fortified milk per day (300 IU) plus a supplement containing vitamin D (600 IU) plus 1 cup of vitamin D fortified orange juice (100 IU). Although this level of vitamin D intake exceeds the AI of 600 IU per day for an elderly person, there is no evidence that consuming this amount will have a detrimental effect on health. No signs of hypercalcemia or hypercalicuria were observed with healthy men and women who were given 4000 IU of vitamin D per day for 2 to 5 months (Vieth et al., 2001). For evaluation of vitamin D status, at-risk individuals should consult their physician.

Summary

Meeting nutrient recommendations is a basic premise of dietary guidance for Americans, but controlling calorie intake also is important. Most Americans consume too little vitamin E, potassium, and fiber; and many consume too little vitamin A, vitamin C, calcium, and magnesium. To meet nutrient recommendations, the Committee recommends that children and adults consume a variety of foods from each of the basic food groups (fruits; vegetables; grains; milk, yogurt, and cheese; and meat, poultry, fish, dry beans, eggs, and nuts). To meet nutrient recommendations while controlling calories, it helps to choose foods that are high in nutrient content but low to moderate in calories and to increase one's level of physical activity.

Additional nutrient recommendations are warranted for a few large subgroups of the population, as follows:

- Adolescents and females of childbearing age need extra iron and folic acid
- Persons over age 50 benefit from taking vitamin B_{12} in its crystalline form from foods fortified with this vitamin or supplements that contain vitamin B_{12}
- The elderly, persons with dark skin, and persons exposed to insufficient UVB radiation need extra vitamin D from vitamin D-fortified foods and/or supplements that contain vitamin D.

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Table D1-1. Nutritional Goals for the USDA Daily Food Intake Pattern

Page 1, Goals for Vitamins[1]

This table shows the nutritional goals for each proposed food intake pattern. The patterns are listed in the left column and are identified by calorie level. The target age/gender group(s) for each pattern are shown, and the goals for each nutrient for that group are then listed. The source of the goal for each nutrient is shown at the top of the column. See the notes page for additional information.

Food pattern (calories)	Nutrient Source of Goal Target age/gender group(s) for pattern[2]	Vitamin A RDA[3] (μg RAE)	Vitamin E RDA[3] (mg AT)	Vitamin C RDA[3] (mg)	Thiamin RDA[3] (mg)	Riboflavin RDA[3] (mg)	Niacin RDA[3] (mg)	Vitamin B_6 RDA[3] (mg)	Folate RDA[3] (μg)	Vitamin B_{12} RDA[3] (μg)
1000	child 1-3	300	6	15	0.5	0.5	6	0.5	150	0.9
1200	female 4-8	400	7	25	0.6	0.6	8	0.6	200	1.2
1400	male 4-8	400	7	25	0.6	0.6	8	0.6	200	1.2
1600	female 9-13	600	11	45	0.9	0.9	12	1.0	300	1.8
	female 51-70, 70+	700	15	75	1.1	1.1	14	1.5	400	2.4
1800	male 9-13	600	11	45	0.9	0.9	12	1.0	300	1.8
	female 14-18	700	15	65	1.0	1.0	14	1.2	400	2.4
	female 31-50	700	15	75	1.1	1.1	14	1.3	400	2.4
2000	male 51-70, 70+	900	15	90	1.2	1.3	16	1.7	400	2.4
	female 19-30	700	15	75	1.1	1.1	14	1.3	400	2.4
2200	male 14-18	900	15	75	1.2	1.3	16	1.3	400	2.4
	male 31-50	900	15	90	1.2	1.3	16	1.3	400	2.4
2400	male 19-30	900	15	90	1.2	1.3	16	1.3	400	2.4
2600[7]	male 19-30	900	15	90	1.2	1.3	16	1.3	400	2.4
2800[7]	male 14-18	900	15	75	1.2	1.3	16	1.3	400	2.4
3000[7]	male 19-30	900	15	90	1.2	1.3	16	1.3	400	2.4
3200[7]	male 14-18	900	15	75	1.2	1.3	16	1.3	400	2.4

Table D1-1 (cont.). Nutritional Goals for the USDA Daily Food Intake Pattern

Page 2, Goals for Minerals[1]

This table shows the nutritional goals for each proposed food intake pattern. The patterns are listed in the left column and are identified by calorie level. The target age/gender group(s) for each pattern are shown and the goals for each nutrient for that group are then listed. The source of the goal for each nutrient is shown at the top of the column. See the notes page for additional information.

Food pattern (calories)	**Nutrient source of Goal Target age/ gender group(s) for pattern[2]**	**Calcium AI[3] (mg)**	**Phosphorus RDA[3] (mg)**	**Magnesium RDA[3] (mg)**	**Iron RDA[3] (mg)**	**Zinc RDA[3] (mg)**	**Copper RDA[3] (µg)**	**Sodium UL (2004)[3,4] (mg)**	**Potassium AI (2004)[3,4] (mg)**
1000	child 1-3	500	460	80	7	3	340	<1500	3000
1200	female 4-8	800	500	130	10	5	440	<1900	3800
1400	male 4-8	800	500	130	10	5	440	<1900	3800
1600	female 9-13	1300	1250	240	8	8	700	<2200	4500
	female 51-70, 70+	1200	700	320	8	8	900	<2300	4700
1800	male 9-13	1300	1250	240	8	8	700	<2200	4500
	female 14-18	1300	1250	360	15	9	890	<2300	4700
	female 31-50	1000	700	320	18	8	900	<2300	4700
2000	male 51-70, 70+	1200	700	420	8	11	900	<2300	4700
	female 19-30	1000	700	310	18	8	900	<2300	4700
2200	male 14-18	1300	1250	410	11	11	890	<2300	4700
	male 31-50	1000	700	420	8	11	900	<2300	4700
2400	male 19-30	1000	700	400	8	11	900	<2300	4700
2600[7]	male 19-30	1000	700	400	8	11	900	<2300	4700
2800[7]	male 14-18	1300	1250	410	11	11	890	<2300	4700
3000[7]	male 19-30	1000	700	400	8	11	900	<2300	4700
3200[7]	male 14-18	1300	1250	410	11	11	890	<2300	4700

Table D1-1 (cont.). Nutritional Goals for the USDA Daily Food Intake Pattern

This table shows the nutritional goals for each proposed food intake pattern. The patterns are listed in the left column and are identified by calorie level. The target age/gender group(s) for each pattern are shown and the goals for each nutrient for that group are then listed. The source of the goal for each nutrient is shown at the top of the column. See the notes page for additional information.

	Nutrient source of goal	Protein		Carbohydrate		Added sugars	Total fiber	Total fat	Saturated fat	Cholesterol	Linoleic acid		α-linolenic acid	
		RDA[3]	AMDR[3]	RDA[3]	AMDR[3]	See Note 5	See Note 6	AMDR[3]	DG[3]	DV[3]	AI[3]	AMDR[3]	AI[3]	AMDR[3]
Food pattern (calories)	**Target age/ gender group(s) for pattern[2]**	(g)	(%)	(g)	(%)	(%)	(g)	(%)	(%)	(mg)	(g)	(%)	(g)	(%)
1000	child 1-3	13	5-20	130	45-65	<25%	14	30-40	<10%	<300	7	5-10	0.7	0.6-1.2
1200	female 4-8	19	10-30	130	45-65	<25%	17	25-35	<10%	<300	10	5-10	0.9	0.6-1.2
1400	male 4-8	19	10-30	130	45-65	<25%	20	25-35	<10%	<300	10	5-10	0.9	0.6-1.2
1600	female 9-13	34	10-30	130	45-65	<25%	22	25-35	<10%	<300	10	5-10	1.0	0.6-1.2
	female 51-70, 70+	46	10-35	130	45-65	<25%	22	20-35	<10%	<300	11	5-10	1.1	0.6-1.2
1800	male 9-13	34	10-30	130	45-65	<25%	25	25-35	<10%	<300	12	5-10	1.2	0.6-1.2
	female 14-18	46	10-30	130	45-65	<25%	25	25-35	<10%	<300	11	5-10	1.1	0.6-1.2
	female 31-50	46	10-35	130	45-65	<25%	25	20-35	<10%	<300	12	5-10	1.1	0.6-1.2
2000	male 51-70, 70+	56	10-35	130	45-65	<25%	28	20-35	<10%	<300	14	5-10	1.6	0.6-1.2
	female 19-30	46	10-35	130	45-65	<25%	28	20-35	<10%	<300	12	5-10	1.1	0.6-1.2
2200	male 14-18	52	10-30	130	45-65	<25%	31	25-35	<10%	<300	16	5-10	1.6	0.6-1.2
	male 31-50	56	10-35	130	45-65	<25%	31	20-35	<10%	<300	17	5-10	1.6	0.6-1.2
2400	male 19-30	56	10-35	130	45-65	<25%	34	20-35	<10%	<300	17	5-10	1.6	0.6-1.2
2600[7]	male 19-30	56	10-35	130	45-65	<25%	36	20-35	<10%	<300	17	5-10	1.6	0.6-1.2
2800[7]	male 14-18	52	10-30	130	45-65	<25%	39	25-35	<10%	<300	16	5-10	1.6	0.6-1.2
3000[7]	male 19-30	56	10-35	130	45-65	<25%	42	20-35	<10%	<300	17	5-10	1.6	0.6-1.2
3200[7]	male 14-18	52	10-30	130	45-65	<25%	45	25-35	<10%	<300	16	5-10	1.6	0.6-1.2

Notes for Table D1-1:

[1]Nutritional goals are from Institute of Medicine (IOM) *Dietary Reference Intakes* reports, 1997–2004 (RDA, AI, AMDR, UL); from Food and Drug Administration Daily Values for Nutrition Facts Labels (DV); and from the Dietary Guidelines for Americans, 2000 (DG).

[2]Target groups are based on estimated energy requirements of sedentary individuals of reference height and weight from IOM *Dietary Reference Intakes* report for macronutrients, 2002.

[3]Nutritional goals based on Recommended Dietary Allowances (RDA), Adequate Intakes (AI), Daily Values (DV), Upper Limits (UL), Acceptable Macronutrient Distribution Ranges (AMDR), or Dietary Guidelines (DG) recommendations. AMDR are shown as a percentage of total calories.

[4]Standards for sodium and potassium have been updated since the original release of this table, and now are based on the *Dietary Reference Intakes* report for fluids and electrolytes, February 2004. The standard used for sodium is a moderation goal, to be no more than the UL, and for potassium, an adequacy goal, to be at least the AI.

[5]Added sugars: The reference amount is based on the suggestion from the *Dietary Reference Intakes* macronutrients report. In determining the Food Guide Pyramid daily food intake pattern, amounts of added sugars in each pattern are calculated according to the calories that remain available, up to the energy goal, after food group and fat calories are considered.

[6]Estimated total fiber recommendation is based on 14 g of total fiber per 1000 calories, the basis for the total fiber AI recommendation in the DRI macronutrients report. Additional explanation for this choice is found in the text of the *Federal Register* notice.

[7]The food pattern at the 2,600-, 2,800-, 3,000-, and 3,200-calorie levels is not the target pattern for any age/gender group, but it is the suggested pattern for more active men. Sample comparisons with the nutritional goals for males age 14 to 18 years and 19 to 30 years are listed here.

Table D1-2. Probabilities of adequacy for selected nutrients on the first 24-hour recall among adult CSFII 1994–1996 participants (nutrients considered "shortfall" nutrients in bold)

Nutrient	Probability of Adequacy (as a percentage)	
	Men	Women
Vitamin A	**47.0%**	**48.1%**
Vitamin C	**49.3**	**52.3**
Vitamin E	**14.1**	**6.8**
Thiamin	83.9	72.2
Riboflavin	85.8	80.9
Niacin	90.5	80.4
Folate[1]	**33.9**	**20.9**
Vitamin B_6	78.3	60.7
Vitamin B_{12}	80.5	64.2
Phosphorus	94.3	85.1
Magnesium	**36.1**	**34.3**
Iron	95.5	79.4
Copper	87.4	73.3
Zinc	65.7	62.0
Calcium	**58.6**	**45.7**

[1]The probability of folate adequacy is underestimated because the folate intake values are expressed in milligrams of folate rather than dietary folate equivalents (DFEs), the unit used in Dietary Reference Intakes. DFEs account for the higher percent absorption of folate from foods fortified with folic acid, whereas milligrams of folate do not. Moreover, the food intake data from 1994–1996 do not reflect the current fortification of enriched grains with folic acid, required since 1998.

Source: Foote, et al., 2004

Note: This table identifies the probability of *adequacy* for a nutrient, whereas Table D1-4 identifies the probability of *inadequacy* for a nutrient.

Table D1-3. Mean dietary intakes of potassium and fiber in comparison to the adequate intake (AI)

		AI	Mean Intake[1,2]
Potassium	Males		
	<6 yrs.	3000 mg (1-3 yrs.)	2073 mg
	6-11yrs.	3800 mg (4-8 yrs.)	2255 mg
	12-19yrs.	4500 mg (9-13 yrs.)	2781 mg
		4700 mg (14-18 yrs.)	
	20-39yrs.	4700 mg	3114 mg
	40-59yrs.	4700 mg	3332 mg
	60 yrs. and over	4700 mg	3059 mg
	Females		
	<6 yrs.	3000 mg (1-3 yrs.)	1861 mg
	6-11yrs.	3800 mg (4-8 yrs)	2122 mg
	12-19yrs.	4500 mg (9-13 yrs.)	2162 mg
		4700 mg (14-18 yrs.)	
	20-39yrs.	4700 mg	2348 mg
	40-59yrs.	4700 mg	2523 mg
	60 yrs. and over	4700 mg	2367 mg
Fiber	Males		
	1-8 yrs.	19g (1-3 yrs.) 25 g (4-8 yrs.)	9.1 g (M/F<6 yrs.)
	9-18yrs.	31g (9-13 yrs.) 38 g (14-18 yrs.)	13.6 g (6-11 yrs.)
	19-50yrs.	38g	17.4 g (12-19 yrs.)
	51 yrs. and over	30g	18.3 g (20-29 yrs.)
			19.4 g (30-39 yrs.)
			18.3 g (40-49 yrs.)
			18.5 g (50-59, 60-69 yrs.)
			17.7 g (70 and over)
	Females		
	1-8 yrs.	19g (1-3 yrs.) 25 g (4-8 yrs.)	9.1 g (M/F <6 yrs.)
	9-18yrs.	31g (9-13 yrs.) 38 g (14-18 yrs.)	12.2 g (6-11 yrs.)
	19-50yrs.	25g	13.0 g (12-19 yrs.)
	51 yrs. and over	21g	13.2 g (20-29 yrs.)
			13.6 g (30-39 yrs.)
			14.0 g (40-49 yrs.)
			14.5 g (50-59 yrs.)
			14.2 g (60-69, 70 and over)

Sources:

[1]For potassium: Ervin et al., 2004.

[2]For fiber: Agricultural Research Service, Results from USDA's 1994–1996 Continuing Survey of Food Intakes by Individuals (CSFII) Table Set 10.

[3]Agricultural Research Service, analysis of CSFII 1994–1996, 1998 data.

Table D1-4. Percentage of school-aged children whose usual daily nutrient intake was below the estimated average requirement (EAR) for all children and by age and gender, 1994–1996 (nutrients considered "shortfall" nutrients in bold)

Nutrient	All	M 6-8	F 6-8	M 9-13	F 9-13	M 14-18	F 14-18
Vitamin A	10.1	0	0	3	6	15	24
Vitamin C	10.5	1	0	2	9	18	22
Vitamin E	**78.9**	**48**	**68**	**70**	**85**	**84**	**99**
Thiamin	1.9	0	0	9	0	2	10
Riboflavin	2.1	0	0	0	0	3	5
Niacin	1.9	0	0	0	0	0	5
Vitamin B_6	1.3	0	0	0	2	3	15
Folate[1]	**50.6**	**13**	**14**	**36**	**59**	**58**	**90**
Vitamin B_{12}	1.3	0	0	0	1	0	8
Phosphorus	19.9	0	0	15	37	7	48
Magnesium	**36.5**	**1**	**0**	**16**	**33**	**62**	**89**
Iron	2.9	1	1	0	0	1	13
Zinc	8.2	0	0	1	11	3	24

[1]The percentage of children with folate intakes below the EAR is overestimated because the probability of folate adequacy is underestimated because the folate intake values are expressed in mcg of folate rather than dietary folate equivalents (DFEs), the unit used in Dietary Reference Intakes. DFEs account for the higher percent absorption of folate from foods fortified with folic acid, whereas mcg of folate do not. Moreover, the food intake data from 1994–1996 do not reflect the current fortification of enriched grains with folic acid, required since 1998.

Source: Suitor and Gleason, 2002

Note: This table identifies the probability of *inadequacy* for a nutrient, while Table D1-2 identifies the probability of *adequacy* for a nutrient.

Table D1-5. Food Sources of Vitamin A

Table D1-5a. Food sources of vitamin A ranked by mcg RAE of vitamin A per standard amount; also calories in the standard amount. (All are ≥ 20% of RDA for adult men, which is 900 mcg RAE.)

Food, standard amount	Vitamin A (mcg RAE)[1]	Calories[1]
Organ meats (liver, giblets), various, cooked, 3 ounces	1490-9126	134-276
Carrot juice, ¾ cup	1692	71
Sweet potato with peel, baked, 1 medium	1096	103
Pumpkin, canned, ½ cup	953	42
Carrots, cooked from fresh, ½ cup	671	27
Spinach, cooked from frozen, ½ cup	573	30
Collards, cooked from frozen, ½ cup	489	31
Kale, cooked from frozen, ½ cup	478	20
Mixed vegetables, canned, ½ cup	474	40
Turnip greens, cooked from frozen, ½ cup	441	24
Carrot, raw, 1 small	301	20
Instant cooked cereals, fortified, prepared, 1 packet	280-285	75-97
Beet greens, cooked, ½ cup	276	19
Winter squash, cooked, ½ cup	268	38
Dandelion greens, cooked, ½ cup	260	18
Various ready-to-eat cereals, ~1 ounce	123 to 230	100-117
Mustard greens, cooked, ½ cup	221	11
Pickled herring, 3 ounces	219	222
Green leaf lettuce, 1 cup	207	8
Red sweet pepper, cooked, ½ cup	187	19
Chinese cabbage, cooked, ½ cup	180	10

Table D1-5b. Food sources of vitamin A as consumed by Americans[2] (percent of total consumption, CSFII, 1994–1996)

Food	Percent of total[3]
Carrots	26.9
Milk	9.0
Organ meats	7.0
Ready-to-eat cereal	6.2
Cheese	5.0
Margarine	4.7
Tomatoes	4.2
Eggs	3.6
Spinach/greens	3.5
Sweet potatoes	3.2
Ice cream/sherbet/ frozen yogurt	2.0

[1]Source: Agricultural Research Service Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.
[2]Source: Cotton et al., 2004. Data are for persons aged 19 years and older, day 1 intakes.
[3] Food groups (n = 9) contributing at least 1% in descending order: cakes/cookies/quick breads/doughnuts, cantaloupe, butter, tomato/vegetable juices, hot breakfast cereal, broccoli, meal replacements/protein supplements, peppers, and pies/crisps/cobblers.

Table D1-6. Food Sources of Vitamin C

Table D1-6a. Food sources of vitamin C ranked by milligrams of vitamin C per standard amount; also calories in the standard amount. (All are ≥ 20% of RDA for adult men, which is 90 mg.)

Food, standard amount	Vitamin C (mg)[1]	Calories[1]
Guava, raw, ½ cup	151	44
Red pepper, sweet, raw, ½ cup	142	20
Red pepper, sweet, cooked, ½ cup	116	19
Orange juice, ¾ cup	61 to 93	74 to 84
Grapefruit juice, ¾ cup	50 to 70	71 to 86
Kiwi fruit, 1 medium	70	46
Orange, raw, 1 medium	70	62
Green pepper, sweet, raw, ½ cup	60	15
Broccoli, cooked, ½ cup	51	26
Green pepper, sweet, cooked, ½ cup	51	19
Vegetable juice cocktail, ¾ cup	50	23
Strawberries, raw, ½ cup	49	27
Brussels sprouts, cooked, ½ cup	48	33
Cantaloupe, ¼ medium	47	51
Papaya, raw, ¼ medium	47	30
Kohlrabi, cooked, ½ cup	45	24
Broccoli, raw, ½ cup	39	15
Edible pod peas, cooked, ½ cup	38	42
Sweet potato, canned, ½ cup	34	116
Tomato juice, ¾ cup	33	31
Cauliflower, cooked, ½ cup	28	17
Pineapple, raw, ½ cup	28	37
Kale, cooked, ½ cup	27	18
Mango, ½ cup	23	54

Table D1-6b. Food sources of vitamin C as consumed by Americans[2] (percent of total consumption, CSFII, 1994–1996)

Food	Percent of total[3]
Orange/grapefruit juice	23.8
Fruit drinks	10.0
Tomatoes	9.9
Peppers	6.7
Potatoes (white)	5.8
Broccoli	5.7
Oranges/tangerines	4.1
Other juice (not citrus)	2.5
Cantaloupe	2.4
Milk	< 2.0
Cabbage	< 2.0
Ready-to-eat cereal	< 2.0

[1]Source: Agricultural Research Service Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.

[2]Source: Cotton et al., 2004. Data are for persons aged 19 years and older, day 1 intakes.

[3] Food groups (n = 12) contributing at least 1% in descending order: milk, bananas, cabbage, strawberries, spinach/greens, potato chips/corn chips/popcorn, grapefruit, other melon (not cantaloupe) ready-to-eat cereal, lettuce, and peas.

Table D1-7. Food Sources of Magnesium

Table D1-7a. Food sources of magnesium ranked by milligrams of magnesium per standard amount; also calories in the standard amount. (All are ≥ 10% of RDA for adult men, which is 420 mg.)

Food, standard amount	Magnesium (mg)[1]	Calories[1]
Pumpkin/squash seed kernels, roasted, 1 ounce	151	148
Bran RTE cereal (100%), ½ cup	114	78
Brazil nuts, 1 ounce	107	186
Halibut, cooked, 3 ounces	91	119
Quinoa, ¼ cup	89	159
Spinach, canned, ½ cup	81	25
Almonds, 1 ounce	78	164
Spinach, cooked from fresh, ½ cup	78	20
Buckwheat flour, ¼ cup	75	101
Cashews, dry roasted, 1 ounce	74	163
Soybeans, mature, cooked, ½ cup	74	149
Pine nuts, dried, 1 ounce	71	191
Mixed nuts with peanuts, 1 ounce	67	175
White beans, canned, ½ cup	67	154
Pollock, walleye, cooked, 3 ounces	62	96
Black beans, cooked, ½ cup	60	114
Tofu, firm, nigari, ½ c	58	97
Bulgur, dry, ¼ cup	57	120
Oat bran, raw, ¼ cup	55	58
Navy beans, cooked, ½ cup	54	129
Soybeans, green, cooked, ½ cup	54	127
Tuna, yellow fin, cooked, 3 ounces	54	118
Artichokes, cooked, ½ cup	50	42
Peanuts, dry roasted, 1 ounce	50	166
Beet greens, cooked, ½ cup	49	19
Lima beans, baby, cooked from frozen, ½ cup	47	95
Okra, cooked from frozen, ½ cup	47	26
Soymilk, 1 cup	47	120
Cowpeas, cooked, ½ cup	46	100
Hazelnuts, 1 ounce	46	178
Oat bran muffin, 1 ounce	45	77
Great northern beans, cooked, ½ cup	44	105
Oat bran, cooked, ½ cup	44	44
Buckwheat groats, roasted, cooked, ½ cup	43	78
Brown rice, cooked, ½ cup	42	108
Haddock, cooked, 3 ounces	42	95

Table D1-7b. Food sources of magnesium as consumed by Americans[2] (percent of total consumption, CSFII, 1994-1996)

Food	Percent of total[3]
Milk	8.3
Yeast bread	7.7
Coffee	6.5
Ready-to-eat cereal	4.9
Potatoes (white)	4.7
Beef	4.3
Poultry	3.4
Dried beans/lentils	3.4
Tomatoes	3.1
Alcoholic beverages	2.9
Potato chips/corn chips/popcorn	2.8
Cakes/cookies/quick breads/doughnuts	2.6
Pasta	2.6
Orange/grapefruit juice	2.4
Nuts/seeds	2.3
Cheese	2.2
Fish/shellfish (excluding canned tuna)	<2.0

[1]Source: Agricultural Research Service Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.

[2]Source: Cotton et al., 2004. Data are for persons aged 19 years and older, day 1 intakes.

[3] Food groups (n = 12) contributing at least 1% in descending order: bananas, rice/cooked grains, fish/shellfish (excluding canned tuna), tea, ice cream/sherbet/frozen yogurt, hot breakfast cereal, soft drinks/soda, tortillas/tacos, meal replacements/protein supplements, candy, flour/baking ingredients, and spinach/greens.

Table D1-8. Food Sources of Vitamin E

Table D1-8a. Food sources of vitamin E ranked by milligrams of vitamin E per standard amount; also calories in the standard amount (All provide ≥ 10% of RDA for vitamin E for adults, which is 15 mg α–tocopherol [AT].)

Food, standard amount	mg AT[1]	Calories[1]
Fortified ready-to-eat cereals, ~1 ounce	6.9 – 17.4	88 – 132
Almonds, 1 oz	7.3	164
Sunflower seeds, dry roasted, 1 oz	6.0	165
Sunflower oil, high linoleic, 1 Tbsp	5.6	120
Cottonseed oil, 1 Tbsp	4.8	120
Safflower oil, high oleic, 1 Tbsp	4.6	120
Hazelnuts (filberts), 1 oz	4.3	178
Avocado, raw, 1 each	4.2	322
Mixed nuts, dry roasted, 1 oz	3.1	168
Tomato paste, ¼ cup	2.8	54
Pine nuts, 1 oz	2.6	191
Peanut butter, 2 Tbsp	2.5	192
Tomato puree, ½ cup	2.5	48
Tomato sauce, ½ cup	2.5	39
Canola oil, 1 Tbsp	2.4	124
Wheat germ, toasted, plain, 2 Tbsp	2.3	54
Peanuts, 1 oz	2.2	166
Turnip greens, frozen, cooked, ½ cup	2.2	24
Carrot juice, canned, ¾ cup	2.1	71
Peanut oil, 1 Tbsp	2.1	119
Corn oil, 1 Tbsp	1.9	120
Olive oil, 1 Tbsp	1.9	119
Spinach, cooked, ½ cup	1.9	21
Dandelion greens, cooked, ½ cup	1.8	18
Sardine, Atlantic, in oil, drained, 3 oz	1.7	177
Blue crab, cooked/canned, 3 oz	1.6	84
Brazil nuts, 1 oz	1.6	186
Herring, Atlantic, pickled, 3 oz	1.5	222

Table D1-8b. Food sources of vitamin E as consumed by Americans[2] (percent total consumption, CSFII, 1994–1996)

Food	Percent of total[3]
Salad dressing/ Mayonnaise	12.0
Oils	9.5
Ready-to-eat cereal	7.9
Margarine	7.6
Cakes/cookies/quick breads/doughnuts	7.3
Tomatoes	7.0
Nuts/seeds	4.2
Yeast bread	3.7
Chips* and popcorn	3.4
Other fats**	3.4
Eggs	2.3
Meal replacement/ protein supplements	<2.0
Fish/shellfish***	<2.0

*Potato and corn chips
**Shortening/animal fat
***Excl. canned tuna

[1]Source: Agricultural Research Service Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.

[2]Source: Cotton et al., 2004. Data are for persons aged 19 years and older, day 1 intakes.

[3]Additional food groups (n = 11) contributing at least 1% in descending order: pies/crisps/cobblers, broccoli, milk, cheese, biscuits, poultry, beef, crackers/pretzels, and tortillas/tacos.

Table D1-9. Food Sources of Calcium

Table D1-9a. Food sources of calcium ranked by milligrams of calcium per standard amount; also calories in the standard amount. (All are ≥ 20% of AI for adults 19-50, which is 1,000 mg.)

Food, standard amount	Calcium (mg)[1]	Calories[1]
Fortified ready-to-eat cereals (various), 1 ounce	350 – 1000	74 – 120
Plain yogurt, nonfat (13g protein/8 oz), 8 ounces	452	127
Romano cheese, 1.5 ounces	452	165
Pasteurized process Swiss cheese, 2 ounces	438	190
Tofu, raw, regular, prepared with calcium sulfate, ½ cup	434	94
Plain yogurt, low fat (12 g protein/8 oz), 8 ounces	415	143
Fruit yogurt, low fat (10 g protein/8 oz), 8 ounces	345	232
Swiss cheese, 1.5 ounces	336	162
Ricotta cheese, part skim, ½ cup	335	170
Sardines, canned in oil, drained, 3 ounces	325	177
Pasteurized process American cheese food, 2 ounces	323	188
Provolone cheese, 1.5 ounces	321	150
Mozzarella cheese, part-skim, 1.5 ounces	311	129
Cheddar cheese, 1.5 ounces	307	171
Skim milk, 1 cup	306	83
Muenster cheese, 1.5 ounces	305	156
1% low-fat milk, 1 cup	290	102
Low-fat chocolate milk (1%), 1 cup	288	158
2% reduced fat milk, 1 cup	285	122
Reduced fat chocolate milk (2%), 1 cup	285	180
Buttermilk, low-fat, 1 cup	284	98
Chocolate milk, 1 cup	280	208
Sesame seeds, roasted and toasted, 1 ounce	280	160
Whole milk, 1 cup	276	146
Yogurt, plain, whole milk (8 g protein/8 oz), 8 ounces	275	138
Ricotta cheese, whole milk, ½ cup	255	214
Blue cheese, 1.5 ounces	225	150
Mozzarella cheese, whole milk, 1.5 ounces	215	128
Feta cheese, 1.5 ounces	210	113
Tofu, firm, prepared with nigari, ½ cup	204	97

Table D1-9b. Food sources of calcium as consumed by Americans[2] (percent of total consumption, CSFII, 1994–1996)

Food	Percent of total[3]
Milk	28.3
Cheese	19.6
Yeast bread	8.9
Ice cream/sherbet/ frozen yogurt	4.0
Cakes/cookies/quick breads/doughnuts	2.4

[1]Source: Agricultural Research Service Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.

[2]Source: Cotton et al., 2004. Data are for persons aged 19 years and older, day 1 intakes.

[3] Food groups (n = 11) contributing at least 1% in descending order: yogurt, ready-to-eat cereal, soft drinks/soda, tortillas/tacos, eggs, dried beans/lentils, tomatoes, meal replacements/protein supplements, corn bread/corn muffins, hot breakfast cereal, and coffee.

Table D1-10. Food Sources of Potassium

Table D1-10a. Food sources of potassium ranked by milligrams of potassium per standard amount, also showing calories in the standard amount. (The AI for adults is 4700 mg potassium.)

Food, standard amount	Potassium (mg)[1]	Calories
Sweet potato, baked, 1 potato (146 g)	694	131
Tomato paste, ¼ cup	664	54
Beet greens, cooked, ½ cup	655	19
Potato, baked, flesh, 1 potato (156 g)	610	145
White beans, canned, ½ cup	595	153
Yogurt, plain, nonfat, 8 oz container	579	127
Tomato puree, ½ cup	549	48
Clams, canned, 3 oz	534	126
Yogurt, plain, low fat, 8 oz container	531	143
Prune juice, ¾ cup	530	136
Carrot juice, ¾ cup	517	71
Blackstrap molasses, 1 Tbsp	498	47
Halibut, cooked, 3 oz	490	119
Soybeans, green, cooked, ½ cup	485	127
Tuna, yellow fin, cooked, 3 oz	484	118
Lima beans, cooked, ½ cup	478	108
Winter squash, cooked, ½ cup	448	57
Soybeans, mature, cooked, ½ cup	443	149
Rockfish, Pacific, cooked, 3 oz	442	103
Cod, Pacific, cooked, 3 oz	439	89
Bananas, 1 medium	422	105
Spinach, cooked, ½ cup	419	21
Tomato juice, ¾ cup	417	31
Tomato sauce, ½ cup	405	39
Peaches, dried, uncooked, ¼ cup	398	96
Prunes, stewed, ½ cup	398	133
Milk, nonfat, 1 cup	382	83
Pork chop, center loin, cooked, 3 oz	382	197
Apricots, dried, uncooked, ¼ cup	378	78
Rainbow trout, cooked, 3 oz	375	144
Pork loin, center rib (roasts), lean, roasted, 3 oz	371	190
Buttermilk, cultured, low fat, 1 cup	370	98
Cantaloupe, ¼ medium	368	47
1% milk, 1 cup	366	102
2% milk, 1 cup	366	122
Honeydew melon, 1/8 medium	365	58

Table D1-10b. Food sources of potassium as consumed by Americans[2] (percent of total consumption, CSFII, 1994–1996)

Food	Percent of total[3]
Milk	10.2%
Potatoes (white)	8.9%
Coffee	6.7%
Beef	6.2%
Tomatoes	6.2%
Orange/grapefruit juice	4.1%
Yeast bread	3.6%
Poultry	3.3%
Dried beans/lentils	2.8%
Bananas	2.7%
Potato/corn chips, popcorn	2.3%
Tea	2.0%
Fish/shellfish (excl. canned tuna)	<2.0%

Table D1-10 (cont). Food Sources of Potassium

Food, standard amount	**Potassium (mg)**[1]	**Calories**
Lentils, cooked, ½ cup	365	115
Plantains, cooked, ½ cup	358	90
Kidney beans, cooked, ½ cup	357	113
Orange juice, ¾ cup	355	85
Split peas, cooked, ½ cup	355	116
Yogurt, plain, whole milk, 8 oz container	352	138

[1]Source: ARS Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.

[2]Source: Cotton et al., 2004. Data are for persons aged 19 years and older, day 1 intakes.

[3]Additional food groups (n = 11) contributing at least 1% in descending order: ice cream/sherbet/frozen yogurt, ready-to-eat cereal, fish/shellfish (excluding canned tuna). Cakes/cookies/quick breads/doughnuts, alcoholic beverages, cheese, pork (fresh/unprocessed), lettuce, ham, carrots, and onions.

Table D1-11. Food Sources of Dietary Fiber

Table D1-11a. Food sources of dietary fiber ranked by grams of dietary fiber per standard amount; also calories in the standard amount (All are ≥ 10% of AI for adult women, which is 25 g.)

Food, standard amount	Dietary fiber (g)[1]	Calories[1]
Bran ready-to-eat cereal (100%), ½ cup	9.6	78
Kidney beans, canned, ½ cup	8.2	109
Split peas, cooked, ½ cup	8.1	116
Lentils, cooked, ½ cup	7.8	115
Black beans, cooked, ½ cup	7.5	114
Pinto beans, cooked, ½ cup	7.0	120
Lima beans, cooked, ½ cup	6.6	108
Artichoke, globe, cooked, 1 each	6.5	60
White beans, canned, ½ cup	6.3	154
Chickpeas, cooked, ½ cup	6.2	135
Great northern beans, cooked, ½ cup	6.2	105
Navy beans, cooked, ½ cup	5.8	129
Cowpeas, cooked, ½ cup	5.6	100
Soybeans, mature, cooked, ½ cup	5.2	149
Bran ready-to-eat cereals, various, ~1 ounce	2.6-5.1	91-105
Crackers, rye wafers, plain, 2 wafers	5.0	74
Guava, 1 medium	4.9	46
Sweet potato, baked, with peel, 1 medium (146 g)	4.8	131
Asian pear, raw, 1 small	4.4	51
Green peas, cooked, ½ cup	4.4	67
Whole wheat English muffin, 1 each	4.4	134
Pear, raw, 1 small	4.3	81
Bulgur, cooked, ½ cup	4.1	76
Mixed vegetables, cooked, ½ cup	4.0	59
Raspberries, raw, ½ cup	4.0	32
Sweet potato, boiled, no peel, 1 medium (156 g)	3.9	119
Blackberries, raw, ½ cup	3.8	31
Potato, baked, with skin, 1 medium	3.8	240
Soybeans, green, cooked, ½ cup	3.8	127
Stewed prunes, ½ cup	3.8	133
Figs, dried, ¼ cup	3.7	93
Dates, ¼ cup	3.6	126
Oat bran, raw, ¼ cup	3.6	58
Pumpkin, canned, ½ cup	3.6	42
Spinach, frozen, cooked, ½ cup	3.5	30
Almonds, 1 ounce	3.3	164

Table D1-11b. Food sources of dietary fiber as consumed by Americans[2] (percent of total consumption, CSFII, 1994–1996)

Food	Percent of total[3]
Yeast Bread	14.0
Dried beans/lentils	9.2
Potatoes (white)	7.5
Ready-to-eat cereal	6.9
Tomatoes	4.9
Pasta	3.7
Potato/corn chips, popcorn	3.6
Cakes/cookies/quick breads/doughnuts	3.2
Apples/applesauce	2.7
Bananas	2.7
Peas	2.2
Flour/baking ingredients	2.2
Carrots	2.1
Hot breakfast cereals	< 2.0
Corn	< 2.0

Table D1-11 (cont.) Food Sources of Dietary Fiber

Food, standard amount	**Dietary fiber (g)**[1]	**Calories**[1]
Apple with skin, raw, 1 medium	3.3	72
Brussels sprouts, cooked, ½ cup	3.2	33
Whole wheat spaghetti, cooked, ½ cup	3.2	87
Banana, 1 medium	3.1	105
Orange, raw, 1 medium	3.1	62
Oat bran muffin, 1 small	3.0	178
Pearled barley, cooked, ½ cup	3.0	97
Sauerkraut, canned, solids and liquids, ½ cup	3.0	23
Tomato paste, ¼ cup	2.9	54
Winter squash, cooked, ½ cup	2.9	38
Broccoli, cooked, ½ cup	2.8	26
Shredded wheat ready-to-eat cereals, various, ~1 ounce	2.6-2.8	78-95
Parsnips, cooked, ½ cup	2.8	55
Turnip greens, cooked, ½ cup	2.8	24
Collards, cooked, ½ cup	2.7	25
Okra, frozen, cooked, ½ cup	2.6	26
Peas, edible-podded, cooked, ½ cup	2.5	42

[1]Source: ARS Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.

[2]Source: Cotton et al., 2004. Data are for persons aged 19 years and older, day 1 intakes (7).

[3] Food groups (n = 13) contributing at least 1% in descending order: tortillas/tacos, onions, lettuce, nuts/seeds, hot breakfast cereal, broccoli, green beans, corn, rice/cooked grains, crackers/pretzels, pies/crisps/cobblers, oranges/tangerines, spinach/greens.

Table D1-12. Functions of "Shortfall" Nutrients

Nutrient	Function
Vitamin A	Vitamin A plays a significant role in vision, gene expression, cellular differentiation, morphogenesis, growth, immune function, and maintenance of healthy bones, teeth, and hair.
Vitamin C	As a dietary antioxidant, vitamin C counteracts the oxidative damage to biomolecules; in addition, vitamin C helps strengthen blood vessels and maintain healthy gums, and aids in the absorption of iron.
Vitamin E	As a dietary antioxidant, vitamin E counteracts the oxidative damage to biomolecules; in addition, vitamin E helps in the formation of red blood cells and muscles.
Calcium	Calcium is the key nutrient in the development and maintenance of bones; in addition, calcium aids in blood clotting and muscle and nerve functioning.
Magnesium	Magnesium plays a key role in the development and maintenance of bones, as well as activates enzymes necessary for energy release.
Potassium	Potassium assists in muscle contraction, maintaining fluid and electrolyte balance in cells, transmitting nerve impulses, and releasing energy during metabolism. Diets rich in potassium lower blood pressure, blunt the adverse effects of salt on blood pressure, may reduce the risk of developing kidney stones, and may decrease bone loss.
Dietary fiber	Fiber helps maintain the health of the digestive tract and promotes proper bowel functioning.

Table D1-13. Revised USDA Food Intake Pattern for Meeting Recommended Nutrient Intakes

This table shows the suggested amounts of food to consume from the basic food groups, subgroups, and oils to meet recommended nutrient intakes at 12 different calorie levels. Nutrient and energy contributions from each group are calculated according to the nutrient-dense forms of foods in each group (e.g., lean meats and fat-free milk). The table also shows the amount of discretionary calories that can be accommodated within each calorie level, in addition to the suggested amounts of nutrient-dense forms of foods in each group.

	Daily amount of food from each group in pattern (vegetable subgroup amounts are per week)											
Calorie Level	**1,000**	**1,200**	**1,400**	**1,600**	**1,800**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**	**3,000**	**3,200**
Food Group[1]	**Food group amounts shown in cup (c) or ounce equivalents (oz eq), with number of servings (srv) in parentheses when it differs from the other units. See note for quantity equivalents for foods in each group.[2] Oils are shown in grams (g).**											
Fruits	1 c (2 srv)	1 c (2 srv)	1.5 c (3 srv)	1.5 c (3 srv)	1.5 c (3 srv)	2 c (4 srv)	2 c (4 srv)	2 c (4 srv)	2 c (4 srv)	2.5 c (5 srv)	2.5 c (5 srv)	2.5 c (5 srv)
Vegetables[3]	1 c (2 srv)	1.5 c (3 srv)	1.5 c (3 srv)	2 c (4 srv)	2.5 c (5 srv)	2.5 c (5 srv)	3 c (6 srv)	3 c (6 srv)	3.5 c (7 srv)	3.5 c (7 srv)	4 c (8 srv)	4 c (8 srv)
Dark green veg.	1 c/wk	1 ½ c/wk	1 ½ c/wk	2 c/wk	3 c/wk	3 c/wk	3 c/wk	3 c/wk	3 c/wk	3 c/wk	3 c/wk	3 c/wk
Orange veg.	½ c/wk	1 c/wk	1 c/wk	1 ½ c/wk	2 c/wk	2 c/wk	2 c/wk	2 c/wk	2 ½ c/wk	2 ½ c/wk	2 ½ c/wk	2 ½ c/wk
Legumes	½ c/wk	1 c/wk	1 c/wk	2 ½ c/wk	3 c/wk	3 c/wk	3 c/wk	3 c/wk	3 ½ c/wk	3 ½ c/wk	3 ½ c/wk	3 ½ c/wk
Starchy veg.	1½ c/wk	2 ½ c/wk	2 ½ c/wk	2 ½ c/wk	3 c/wk	3 c/wk	6 c/wk	6 c/wk	7 c/wk	7 c/wk	9 c/wk	9 c/wk
Other veg.	4 c/wk	4 ½ c/wk	4 ½ c/wk	5 ½ c/wk	6 ½ c/wk	6 ½ c/wk	7 c/wk	7 c/wk	8 ½ c/wk	8.5 c/wk	10 c/wk	10 c/wk
Grains[4]	3 oz eq	4 oz eq	5 oz eq	5 oz eq	6 oz eq	6 oz eq	7 oz eq	8 oz eq	9 oz eq	10 oz eq	10 oz eq	10 oz eq
Whole grains	1.5	2	2.5	3	3	3	3.5	4	4.5	5	5	5
Other grains	1.5	2	2.5	2	3	3	3.5	4	4.5	5	5	5
Meat and Beans	2 oz eq	3 oz eq	4 oz eq	5 oz eq	5 oz eq	5.5 oz eq	6 oz eq	6.5 oz eq	6.5 oz eq	7 oz eq	7 oz eq	7 oz eq
Milk	2 c	2 c	2 c	3 c	3 c	3 c	3 c	3 c	3 c	3 c	3 c	3 c
Oils[5]	14 g	17 g	18 g	20 g	22 g	24 g	27 g	28 g	31 g	33 g	40 g	46 g
Discretionary calories[6]	145	131	115	100	157	241	242	325	370	374	466	616

Notes for Table D1-13:

[1]**Food items included in each group and subgroup:**

Fruits — All fresh, frozen, canned, and dried fruits and fruit juices: for example, oranges and orange juice, apples and apple juice, bananas, grapes, melons, berries, raisins. In developing the food patterns, only fruits and juices with no added sugars or fats were used. **See note 6 on discretionary calories if products with added sugars or fats are consumed.**

Vegetables — In developing the food patterns, only vegetables with no added fats or sugars were used. **See note 6 on discretionary calories if products with added fats or sugars are consumed.**

Dark green vegetables	All fresh, frozen, and canned dark green vegetables, cooked or raw: for example, broccoli; spinach; romaine; collard, turnip, and mustard greens.
Orange vegetables	All fresh, frozen, and canned orange and deep yellow vegetables, cooked or raw: for example, carrots, sweet potatoes, winter squash, pumpkin.
Legumes (dry beans and peas)	All cooked dry beans and peas and soybean products: for example, pinto beans, kidney beans, lentils, chickpeas, tofu. (See comment under meat and beans group about counting legumes in the vegetable or the meat and beans group.)
Starchy vegetables	All fresh, frozen, and canned starchy vegetables: for example, white potatoes, corn, green peas.
Other vegetables	All fresh, frozen, and canned other vegetables, cooked or raw: for example, tomatoes, tomato juice, lettuce, green beans, onions.
Grains	In developing the food patterns, only grains in low-fat and low sugars forms were used. **See note 6 on discretionary calories if products that are higher in fat and/or added sugars are consumed.**
Whole grains	All whole grain products and whole grains used as ingredients: for example, whole wheat and rye breads, whole grain cereals and crackers, oatmeal, brown rice.
Other grains	All refined grain products and refined grains used as ingredients: for example, white breads, enriched grain cereals and crackers, enriched pasta, white rice.
Meat, poultry, fish, dry beans, eggs, and nuts (meat & beans)	All meat, poultry, fish, dry beans and peas, eggs, nuts, seeds. Most choices should be lean or low fat. **See note 6 on discretionary calories if higher fat products are consumed.** Dry beans and peas and soybean products are considered part of this group as well as the vegetable group, but should be counted in one group only.
Milk, yogurt, and cheese (milk)	All milks, yogurts, frozen yogurts, dairy desserts, cheeses (except cream cheese), including lactose-free and lactose-reduced products. Most choices should be fat-free or low-fat. In developing the food patterns, only fat-free milk was used. **See note 6 on discretionary calories if one consumes low-fat, reduced-fat, or whole milk or milk products—or milk products that contain added sugars.** Calcium-fortified soy beverages are an option for those who want a nondairy calcium source.

[2]**Quantity equivalents for each food group:**

Grains	The following each count as 1 ounce equivalent (1 serving) of grains: ½ cup cooked rice, pasta, or cooked cereal; 1 ounce dry pasta or rice; 1 slice bread; 1 small muffin (1 oz); 1 cup ready-to-eat cereal flakes.
Fruits and vegetables	The following each count as 1 cup (2 servings) of fruits or vegetables: 1 cup cut-up raw or cooked fruit or vegetable, 1 ½ cup fruit or vegetable juice, 2 cups leafy salad greens.
Meat and beans	The following each count as 1 ounce equivalent: 1 ounce lean meat, poultry, or fish; 1 egg; ½ cup cooked dry beans or tofu; 2 Tbsp peanut butter; 1/3 cup nuts, ¼ cup seeds.
Milk	The following each count as 1 cup (1 serving) of milk: 1 cup milk or yogurt, 1½ ounces natural cheese such as Cheddar cheese or 2 ounces process cheese. Discretionary calories must be counted for all choices, except nonfat milk.

[3]**Explanation of vegetable subgroup amounts:**
Vegetable subgroup amounts are shown in this table as weekly amounts, because it would be difficult for consumers to select foods from each subgroup daily. A daily amount that is one-seventh of the weekly amount listed is used in calculations of nutrient and energy levels in each pattern.

[4]**Explanation of grain subgroup amounts:**
The whole grain subgroup amounts shown in this table represent at least three 1-ounce servings and one-half of the total amount as whole grains for all calorie levels of 1,600 and above. This is the minimum suggested amount of whole grains to consume as part of the food patterns. More whole grains up to all of the grains recommended may be selected, with offsetting decreases in the amounts of other (enriched) grains. In patterns designed for younger children (1,000, 1,200, and 1,400 calories), one-half of the total amount of grains is shown as whole grains.

[5]**Explanation of oils:**
Oils (including *trans*-free soft margarine) shown in this table represent the amounts that are added to foods during processing, cooking, or at the table. Oils and soft margarines include vegetable oils and soft vegetable oil table spreads that are *trans*-free. The amounts of oils listed in this table are not considered to be part of discretionary calories because they are a major source of the vitamin E and polyunsaturated fatty acids, including the essential fatty acids, in the food pattern. In contrast, solid fats are listed separately in the discretionary calorie table (Table D1-14) because, compared with oils, they are higher in saturated fatty acids and lower in vitamin E and mono- and poly-unsaturated fatty acids, including essential fatty acids. The amounts of each type of fat in the food intake pattern were based on 60% oils and/or *trans*-free soft margarines and 40% solid fat. The amounts in typical American diets are about 42% oils or soft margarines and about 58% solid fats.

[6]**Discretionary calories** are the remaining amount of calories in each food pattern after selecting the specified number of nutrient-dense forms of foods in each food group. The number of discretionary calories assumes that food items in each food group are selected in nutrient-dense forms (that is, forms that are fat-free or low-fat and that contain no added sugars). Solid fat and sugar calories always need to be counted as discretionary calories, as in the following examples:

- The fat in low-fat, reduced fat, or whole milk or milk products or cheese and the sugar and fat in chocolate milk, ice cream, pudding, etc.
- The fat in higher fat meats (e.g., ground beef with more than 5% fat by weight, poultry with skin, higher fat luncheon meats, sausages)
- The sugars added to fruits and fruit juices with added sugars or fruits canned in syrup
- The added fat and/or sugars in vegetables prepared with added fat or sugars
- The added fats and/or sugars in grain products containing higher levels of fats and/or sugars (e.g., sweetened cereals, higher fat crackers, pies and other pastries, cakes, cookies)

Total discretionary calories should be limited to the amounts shown in the table at each calorie level. Additional information about discretionary calories, including an example of the division of these calories between solid fats and added sugars, is provided in Table D1-14.

Table D1-14. Discretionary Calories in the Revised USDA Food Intake Pattern

Discretionary calories are the remaining amount of calories in each food pattern after nutrient-dense forms of foods in each food group are selected. This table shows the number of discretionary calories remaining in each food intake pattern if nutrient-dense foods are selected. Those trying to lose weight may choose not to use discretionary calories. For those wanting to maintain their weight, discretionary calories may be used to increase the amount of food selected from each food group; to consume foods that are not in the lowest fat form (such as 2% milk or medium-fat meat) or that contain added sugars; to add oil, fat, or sugars to foods; or to consume alcohol. The table shows an example of how these calories may be divided between solid fats and added sugars.

Food pattern calorie level	**Discretionary calories that remain in food patterns at each calorie level**											
	1,000	**1,200**	**1,400**	**1,600**	**1,800**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**	**3,000**	**3,200**
Discretionary calories[1]	145	131	115	100	157	241	242	325	370	374	466	616
Example of division of discretionary calories:												
Solid fats are shown in grams (g); added sugars in grams (g) and teaspoons (tsp).												
Solid fats[2]	10 g	11 g	11 g	10 g	14 g	16 g	18 g	20 g	22 g	22 g	26 g	30 g
Added sugars[3]	16 g (4 tsp)	12 g (3 tsp)	8 g (2 tsp)	8 g (2 tsp)	12 g (3 tsp)	28 g (7 tsp)	28 g (7 tsp)	44 g (11 tsp)	48 g (12 tsp)	52 g (13 tsp)	64 g (16 tsp)	96 g (24 tsp)

[1]**Discretionary calories**: In developing the food patterns, food items in nutrient-dense forms (that is, forms that are fat-free or low-fat and that contain no added sugars) were used. The number of discretionary calories assumes that food items in each food group are selected in nutrient-dense forms. Solid fat and sugar calories always need to be counted as discretionary calories, as in the following examples:

The fat in low-fat, reduced-fat, or whole milk or milk products or cheese and the sugar and fat in chocolate milk, ice cream, pudding, etc.

The fat in higher fat meats (e.g., ground beef with more than 5% fat by weight, poultry with skin, higher fat luncheon meats, sausages)

The sugars added to fruits and fruit juices with added sugars or fruits canned in syrup

The added fat and/or sugars in vegetables prepared with added fat or sugars

The added fats and/or sugars in grain products containing higher levels of fats and/or sugars (e.g., sweetened cereals, higher fat crackers, pies and other pastries, cakes, cookies)

Total discretionary calories should be limited to the amounts shown in the table at each calorie level. The calories assigned to discretionary calories may be used to increase intake from the basic food groups; to select foods from these groups that are higher in fat or with added sugars; to add oils, solid fats or sugars to foods or beverages; or to consume alcohol. See note 2 on limits for solid fats.

[2] **Solid fats:** Amounts of solid fats listed in the table represent about 7 to 8% of calories from saturated fat. Foods in each food group are represented in their lowest fat forms, such as fat-free milk and skinless chicken. Solid fats shown in this table represent the amounts of fats that may be added in cooking or at the table, and fats consumed when higher fat items are selected from the food groups (e.g., whole milk instead of fat-free milk, chicken with skin, or cookies instead of bread), without exceeding the recommended limits on saturated fat intake. Solid fats include meat and poultry fats eaten either as part of the meat or poultry product or separately; milk fat such as that in whole milk, cheese, and butter; shortenings used in baked products; and hard margarines.

Solid fats and oils are separated because their fatty acid compositions differ. Solid fats are higher in saturated fatty acids, and commonly consumed oils and *trans*-free soft margarines are higher in vitamin E and mono- and polyunsaturated fatty acids, including essential fatty acids. Oils listed in Table D1-13 are not considered to be part of discretionary calories because they are a major source of the essential fatty acids and vitamin E in the food pattern. The gram weights for solid fats are the amounts of these products that can be included in the pattern, and are not identical to the amount of lipids in these items, because some products (margarines, butter) contain water or other ingredients, in addition to lipids.

[3] **Added sugars:** Added sugars are the sugars and syrups added to foods and beverages in processing or preparation, not the naturally occurring sugars in fruits or milk. The amounts of added sugars suggested in the example are NOT specific recommendations for amounts of added sugars to consume, but rather represent the amounts that can be included in each food intake pattern without over-consuming calories. The suggested amounts of added sugars may be helpful as part of the food pattern to allow for some sweetened foods or beverages, without exceeding energy needs. This use of added sugars as a calorie balance requires two assumptions: (1) that selections are made from all food groups in accordance with the suggested amounts and (2) that additional fats are used in the amounts shown, which, together with the fats in the core food groups, represent about 30% of calories from fat.

Table D1-15. Nutrient Profiles[1] of the USDA Food Intake Pattern Food Groups and Subgroups

This table shows the nutrient composition of each food group and subgroup. The nutrients are listed for a standard amount from each group, and the values are weighted averages of the nutrients in all foods in each group, in their lowest fat and sugar form. Weights for these average values are based on the amounts of each food consumed by Americans according to national surveys. See the notes page for additional information.

Food groups and subgroups	Standard amount[2]	Vitamin A	Vitamin E	Vitamin C	Thiamin	Riboflavin	Niacin	Vitamin B_6	Folate	Vitamin B_{12}
		µg RAE[3]	mg AT[3]	mg	mg	mg	mg	mg	µg	µg
Fruits	1/2 cup	19	0.2	30	0.07	0.04	0.4	0.1	28	0.0
Vegetables										
Dark green	1/2 cup	167	1.0	30	0.05	0.10	0.4	0.1	81	0.0
Deep yellow	1/2 cup	554	0.6	5	0.19	0.04	0.6	0.1	10	0.0
Legumes	1/2 cup	0	0.6	0	0.11	0.05	0.3	0.1	111	0.0
Starchy	1/2 cup	2	0.0	6	0.09	0.03	1.1	0.2	14	0.0
Other	1/2 cup	12	0.4	10	0.04	0.04	0.5	0.1	17	0.0
Grains[4]										
Whole grains	1 slice/1/2 cup	26	0.1	1	0.12	0.10	1.3	0.1	37	0.3
Other grains	1 slice/1/2 cup	6	0.1	0	0.14	0.09	1.3	0.0	36	0.1
Meat and beans	1 ounce	18	0.2	0	0.06	0.08	1.8	0.1	5	0.6
Milk[5]	1 cup	69	0.0	0	0.11	0.45	0.2	0.1	12	1.3
Oils/soft margarines	100 g	109	14.3	0	0.00	0.00	0.0	0.0	0.1	0.0
Solid fats	100 g	447	4.1	0	0.00	0.02	0.0	0.0	1.4	0.1
Added sugars	4 grams/1 tsp.	0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0

Table D1-15 (cont.). Nutrient Profiles[1] of the USDA Food Intake Pattern Food Groups and Subgroups

Food groups and subgroups	Standard Amount[2]	Calcium	Phosphorus	Magnesium	Iron	Zinc	Copper	Sodium	Potassium
		mg	mg	mg	mg	mg	mg	mg	mg
Fruits	1/2 cup	13	20	15	0.3	0.1	0.07	3	253
Vegetables									
Dark green	1/2 cup	50	39	25	1.0	0.3	0.07	30	229
Deep yellow	1/2 cup	23	25	9	0.3	0.2	0.03	41	214
Legumes	1/2 cup	56	115	43	2.3	1.0	0.23	6	321
Starchy	1/2 cup	8	43	19	0.4	0.3	0.12	5	286
Other	1/2 cup	21	21	10	0.5	0.2	0.06	57	163
Grains[4]									
Whole grains	1 slice/1/2 cup	29	82	27	1.6	0.8	0.07	99	78
Other grains	1 slice/1/2 cup	31	34	7	1.2	0.2	0.06	154	29
Meat and beans	1 ounce	6	63	9	0.6	1.0	0.05	110	96
Milk[5]	1 cup	306	247	27	0.1	1.0	0.03	103	382
Oils/soft margarines	100 g	3	2	0	0.0	0.0	0.00	132	4
Solid fats	100 g	14	13	1	0.1	0.0	0.01	163	16
Added sugars	4 grams/1 tsp.	0	0	0	0.0	0.0	0.00	0	0

Table D1-15 (cont.). Nutrient Profiles[1] of the USDA Food Intake Pattern Food Groups and Subgroups

Food groups and subgroups	Standard amount[2]	Calories	Protein	Carbo-hydrate	Dietary fiber	Total fat	Saturated fat	Mono. fat	Poly. fat	Cholesterol	Linoleic acid	α-linolenic acid
		kcal	g	g	g	g	g	g	g	mg	g	g
Fruits	1/2 cup	70	1	17	1	0.2	0.0	0.0	0.1	0	0.0	0.02
Vegetables												
Dark green	1/2 cup	20	2	4	2	0.2	0.0	0.0	0.1	0	0.0	0.06
Deep yellow	1/2 cup	32	1	7	2	0.1	0.0	0.0	0.1	0	0.1	0.00
Legumes	1/2 cup	113	8	19	6	1.0	0.2	0.2	0.5	0	0.4	0.11
Starchy	1/2 cup	73	2	17	2	0.2	0.0	0.0	0.1	0	0.1	0.01
Other	1/2 cup	17	1	4	1	0.2	0.0	0.0	0.1	0	0.1	0.02
Grains[4]												
Whole grains	1 slice/1/2 cup	78	2	16	2	1.0	0.2	0.3	0.4	0	0.4	0.02
Other grains	1 slice/1/2 cup	84	2	16	1	1.1	0.3	0.4	0.4	1	0.3	0.03
Meat and beans	1 ounce eq.	58	8	0	0	2.7	0.8	1.1	0.4	36	0.4	0.02
Milk[5]	1 cup	83	8	12	0	0.2	0.3	0.1	0.0	5	0.0	0.00
Oils/soft margarines	100 g	838	0	0	0	94.8	14.3	32.7	43.4	0	39.9	3.48
Solid fats	100 g	758	0	0	0	85.4	36.1	32.7	12.5	115	11.0	1.40
Added sugars	4 grams/1 tsp.	16	0	4	0	0.0	0.0	0.0	0.0	0	0.0	0.00

[1]A nutrient profile is the nutrient content of a standardized amount of food from each food group or subgroup. It is calculated based on a weighted average of all foods in the group or subgroup eaten by Americans, as reported in the 1999–2000 NHANES survey. Weights for the nutrient profiles are determined from the relative amounts reported to have been consumed of each food in a particular group or subgroup. Nutrient values for each food group or subgroup have been calculated using values from the USDA Nutrient Data Base, SR16-1.

[2]The standard amount is an amount used in calculating nutrient profiles. It is expressed in volume or weight-equivalent measures. For the major food groups, it represents the amount in one "Pyramid serving" of the food. Serving equivalents for common foods in each group are listed in Note 2 to Table D1-13.

[3]Vitamin A is expressed in μg RAE; vitamin E in mg AT. These units are used in the recent *Dietary Reference Intakes* reports. When values for a food were not available in these units, existing units were converted to obtain an estimate. Vitamin A from carotenoid sources (fruits and vegetables) expressed in μg RE was divided by 2 to obtain an estimate of vitamin A in μg RAE. Vitamin E expressed in mg ATE was multiplied by 0.8 to obtain an estimate of vitamin E in mg AT.

[4]The nutrient profiles for whole grains and other grains include some added nutrients from moderately fortified ready-to-eat cereals. Moderately fortified ready-to-eat cereals were included as part of the nutrient profiles because of their widespread use among Americans.

[5]The nutrient profile for the milk group is based on the nutrients in fat-free fluid milk.

Table D1-16. Nutrients in the USDA Revised Food Intake Pattern
(shown in amounts and percents of RDA, AI, or other recommendations)

Calorie level	Vit. A mcg RAE	Vit. A % RDA	Vit. E mg AT	Vit. E % RDA	Vit. C mg	Vit. C % RDA	Thiamin mg	Thiamin % RDA	Ribofl. mg	Ribofl. % RDA	Niacin mg	Niacin % RDA	Vit. B_6 mg	Vit. B_6 % RDA	Folate µg	Folate % RDA	Vit. B_{12} µg	Vit. B_{12} % RDA
1000	458		4.3		83		1.0		1.5		10.0		1.1		264		4.2	
% REC—1 to 3		153		72		551		198		304		166		222		176		467
1200	610		5.5		93		1.3		1.7		13.7		1.4		344		4.9	
% REC—4 to 8		152		79		370		211		291		171		240		172		410
1400	663		6.2		123		1.5		2.0		17.2		1.7		413		5.6	
% REC—4 to 8	166	152		79		370		211		291		171		240		172		410
1600	862		7.2		131		1.8		2.5		19.6		2.1		495		7.6	
% REC—M/F 9 to 13		144		66		291		197		282		163		208		165		422
% REC—F 51 to 70		123		48		174		161		231		140		139		124		317
1800	1018		8.3		144		2.0		2.7		21.5		2.2		580		7.7	
% REC—F 31-50		145		55		192		181		245		153		173		145		319
% REC—M/F 9 to 13		170		75		320		221		299		179		225		193		425
% REC—F 14-18		145		55		222		199		269		153		187		145		319
2000	1057		9.0		174		2.1		2.8		22.8		2.4		610		7.9	
% REC—F19-30		151		60		232		190		252		163		186		153		331
% REC—M 51-70		117		60		193		174		213		142		142		153		331
2200	1097		9.7		181		2.3		2.9		26.0		2.7		663		8.4	
% REC—M 31-50		122		65		201		194		226		162		211		166		349
% REC—M 14-18		122		65		242		194		226		162		211		166		349
2400	1132		10.1		182		2.5		3.1		28.2		2.9		702		8.8	
% REC—M 19-30		126		68		202		207		237		176		222		176		367
2600	1244		11.0		189		2.7		3.2		30.1		3.1		767		9.0	
% REC—M 19-30		138		74		210		224		248		188		238		192		374
2800	1290		11.7		219		2.9		3.4		32.7		3.3		835		9.4	
% REC—M 14-18		143		78		292		243		261		205		257		209		392
3000	1322		13.1		227		3.0		3.4		33.6		3.5		850		9.4	
% REC—M 19-30		147		87		252		248		264		210		269		212		392
3200	1346		14.1		227		3.0		3.4		33.6		3.5		850		9.4	
% REC—M 14-18		150		94		302		248		265		210		269		212		393

Table D1-16 (cont.). Nutrients in the Revised USDA Food Intake Pattern
(shown in amounts and percents of RDA, AI, or other recommendations)

Calorie level	Calcium mg	Calcium % AI	Phosph. mg	Phosph. % RDA	Magnes. mg	Magnes. % RDA	Iron mg	Iron % RDA	Zinc mg	Zinc % RDA	Copper mg	Copper % RDA	Sodium mg	Sodium % UL	Potass. mg	Potass. % AI
1000	791		908		184		7.5		6.4		0.7		922		2052	
% REC—1 to 3		158		197		230		107		215		195		61		68
1200	854		1074		229		10.2		8.3		0.9		1194		2441	
% REC—4 to 8		107		215		176		102		167		199		63		64
1400	902		1216		269		12.5		10.0		1.1		1435		2843	
% REC—4 to 8		113		243		207		125		200		239		76		75
1600	1253		1614		340		14.5		12.9		1.3		1650		3588	
% REC—M/F 9 to 13		96		129		142		182		161		180		75		80
% REC—F 51 to 70		104		231		106		182		161		140		72		76
1800	1317		1693		368		16.7		13.5		1.4		1846		3853	
% REC—F 31-50		132		242		115		93		168		158		80		82
% REC—M 9 to 13		101		135		153		208		168		203		84		86
% REC—F 14-18		101		135		102		111		150		159		80		82
2000	1333		1746		386		17.3		14.1		1.5		1910		4154	
% REC—F19-30		133		249		125		96		176		169		83		88
% REC—M 51-70		111		249		92		216		128		169		83		88
2200	1376		1875		425		19.4		15.4		1.7		2112		4525	
% REC—M 31-50		138		268		101		242		140		191		92		96
% REC—M 14-18		106		150		104		176		140		193		92		96
2400	1409		1965		446		21.1		16.4		1.8		2298		4624	
% REC—M 19-30		141		281		112		263		149		202		100		98
2600	1462		2065		480		23.2		17.3		2.0		2465		4907	
% REC—M 19-30		146		295		120		290		157		220		107		104
2800	1507		2175		516		25.2		18.4		2.1		2653		5261	
% REC—M 14-18		116		174		126		229		167		240		115		112
3000	1521		2209		531		25.6		18.6		2.2		2697		5496	
% REC—M 19-30		152		316		133		321		169		249		117		117
3200	1522		2210		531		25.7		18.7		2.3		2711		5497	
% REC—M 14-18		117		177		130		233		170		253		118		117

Table D1-16 (cont.). Nutrients in the Revised USDA Food Intake Pattern
(shown in amounts and percents of RDA, AI, or other recommendations)

Calorie level	Calories		Protein		Carbohy.		Fiber		Linoleic acid		A-linolenic acid		Cholesterol	
	kcal	% goal	g	% RDA	g	% RDA	g	% AI	g	% AI	g	% AI	mg	% DV
1000	996		44		140		13		8.7		0.8		96	
% REC—1 to 3		100		336		108		94		125		121		32
1200	1201		56		162		18		10.9		1.1		134	
% REC—4 to 8		100		294		125		104		109		117		45
1400	1401		67		192		21		12.0		1.2		170	
% REC—4 to 8		100		350		147		107		120		128		57
1600	1608		86		215		26		13.3		1.3		210	
% REC—M/F 9 to 13		101		254		165		114		111		107		70
% REC—F 51 to 70		101		188		165		114		121		117		70
1800	1798		91		243		29		15.0		1.5		216	
% REC—F 31-50		100		198		187		115		125		135		72
% REC—M/F 9 to 13		100		267		187		115		125		124		72
% REC—F 14-18		100		198		187		115		136		135		72
2000	1994		96		278		31		16.2		1.6		236	
% REC—F 19-30		100		208		214		111		135		147		79
% REC—M 51-70		100		171		214		111		116		101		79
2200	2209		103		309		35		18.2		1.8		257	
% REC—M 31-50		100		184		238		112		107		112		86
% REC—M 14-18		100		199		238		112		114		112		86
2400	2406		109		341		37		19.4		1.9		278	
% REC—M 19-30		100		195		263		109		114		119		93
2600	2592		114		372		41		21.2		2.1		281	
% REC—M 19-30		100		203		286		112		125		130		94
2800	2804		121		409		44		22.6		2.2		300	
% REC—M 14-18		100		232		315		112		141		138		100
3000	2991		122		433		46		25.9		2.5		304	
% REC—M 19-30		100		218		333		109		152		157		101
3200	3202		122		467		46		28.8		32.8		309	
% REC—M 14-18		100		235		359		104		180		174		103

Table D1-16 (cont.). Nutrients in the Revised USDA Food Intake Patterns.
(shown in amounts and percent of calories for comparison to AMDR or other recommendations)

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Calorie level	Calories kcal	Calories % goal	Protein g	Protein % kcal	Carbohy. g	Carbohy. % kcal	Total fat g	Total fat % kcal	Sat. fat g	Sat. fat % kcal	Mono. fat g	Mono. fat % kcal	Poly. fat g	Poly. fat % kcal	Linoleic acid g	Linoleic acid % kcal	A-linolenic acid g	A-linolenic acid % kcal
1000	996		44		140		31.7		8.7		11.5		9.6		8.7		0.8	
% REC—1 to 3		100		18		56		29		7.8		10		9		7.9		0.8
1200	1201		56		162		39.5		10.5		14.4		12.0		10.9		1.1	
% REC—4 to 8		100		19		54		30		7.9		11		9		8.1		0.8
1400	1401		67		192		44.4		11.8		16.2		13.3		12.0		1.2	
% REC—4 to 8		100		19		55		29		7.6		10		9		7.7		0.7
1600	1608		86		215		48.9		12.9		17.8		14.7		13.3		1.3	
% REC—M/F 9 to 13		101		21		53		27		7.2		10		8		7.4		0.7
% REC—F 51 to 70		101		21		53		27		7.2		10		8		7.4		0.7
1800	1798		91		243		55.6		14.9		20.2		16.6		15.0		1.5	
% REC—F 31-50		100		20		54		28		7.5		10		8		7.5		0.7
% REC—M/F 9 to 13		100		20		54		28		7.5		10		8		7.5		0.7
% REC—F 14-18		100		20		54		28		7.5		10		8		7.5		0.7
2000	1994		96		278		60.8		16.4		22.1		18.0		16.2		1.6	
% REC—F 19-30		100		19		56		27		7.4		10		8		7.3		0.7
% REC—M 51-70		100		19		56		27		7.4		10		8		7.3		0.7
2200	2209		103		309		67.9		18.2		24.7		20.2		18.2		1.8	
% REC—M 31-50		100		19		56		28		7.4		10		8		7.4		0.7
% REC—M 14-18		100		19		56		28		7.4		10		8		7.4		0.7
2400	2406		109		341		73.0		19.7		26.6		21.5		19.4		1.9	
% REC—M 19-30		100		18		57		27		7.4		10		8		7.2		0.7
2600	2592		114		372		79.0		21.1		28.6		23.5		21.2		2.1	
% REC—M 19-30		100		18		57		27		7.3		10		8		7.4		0.7
2800	2804		121		409		83.5		22.1		30.2		25.0		22.6		2.2	
% REC—M 14-18		100		17		58		27		7.1		10		8		7.3		0.7
3000	2991		122		433		93.7		24.5		33.9		28.6		25.9		2.5	
% REC—M 19-30		100		16		58		28		7.4		10		9		7.8		0.8
3200	3202		122		467		102.8		26.8		37.1		31.7		28.8		2.8	
% REC—M 14-18		100		15		58		29		7.5		10		9		8.1		0.8

Table D1-17. Summary of the Nutrient Contributions of Each Food Group, Averaged Over the Food Pattern at all Energy Levels

Food group	Major contribution(s)[1]	Substantial contribution(s) (>10% of total)[2]
Fruit group	Vitamin C	Thiamin Vitamin B_6 Folate Magnesium Copper Potassium Carbohydrate Fiber
Vegetable group	Vitamin A Potassium	Vitamin E Vitamin C Thiamin Niacin Vitamin B_6 Folate Calcium Phosphorus Magnesium Iron Zinc Copper Carbohydrate Fiber Alpha-linolenic acid
Vegetable subgroups:		
Dark green vegetables		Vitamin A Vitamin C
Orange vegetables	Vitamin A	
Legumes		Folate Copper Fiber
Starchy vegetables		Vitamin B_6 Copper
Other vegetables		Vitamin C
Grain group	Thiamin Folate Magnesium Iron Copper Carbohydrate Fiber	Vitamin A Riboflavin Niacin Vitamin B_6 Vitamin B_{12} Calcium Phosphorus Zinc Potassium Protein Linoleic acid Alpha-linolenic acid

Table D1-17 (cont.). Summary of the Nutrient Contributions of Each Food Group, Averaged Over the Food Pattern at all Energy Levels

Food group	Major contribution(s)[1]	Substantial contribution(s) (>10% of total)[2]
Grain subgroups: Whole grains	Folate (tie) Magnesium Iron Copper Carbohydrate (tie) Fiber	Thiamin Riboflavin Niacin Vitamin B_6 Vitamin B_{12} Phosphorus Zinc Protein
Enriched grains	Folate (tie) Thiamin Carbohydrate (tie)	Riboflavin Niacin Iron Copper
Meat, poultry, fish, eggs, and nuts group	Niacin Vitamin B_6 Zinc Protein	Vitamin E Thiamin Riboflavin Vitamin B_{12} Phosphorus Magnesium Iron Copper Potassium Linoleic acid
Milk group	Riboflavin Vitamin B_{12} Calcium Phosphorus	Vitamin A Thiamin Vitamin B_6 Magnesium Zinc Potassium Carbohydrate Protein
Oils and soft margarines	Vitamin E Linoleic acid Alpha-linolenic acid	

[1]A **major contribution means** that the food group or subgroup provides more of the nutrient than any other single food group, averaged over all calorie levels. When two food groups or subgroups provide equal amounts, it is noted as a tie.

[2]A **substantial contribution** means that the food group or subgroup provides 10% or more of the total amount of the nutrient in the food pattern, averaged over all calorie levels.

Table D1-18. Comparison of Selected Nutrients in the DASH[a] Diet, the Revised USDA Food Intake Pattern, and Nutrient Intake Recommended by the Institute of Medicine

Nutrient[b]	**DASH diet**[c] **(2100 kcals)**	**USDA Food Intake Pattern (2000 & 2200 kcals)**	**IOM recommendations RDA/AI/AMDR**[d]
Protein, g	94.3	96-103	56
Protein, % kcal	18	19	10-35%
Carbohydrate, g	306	278-313	130
Carbohydrate, % kcal	58	56	45-65%
Total fat, g	63.1	60.8-67.1	-
Total fat, % kcal	27	27	20-35%
Saturated fat, g	14.4	16.4-17.8	-
Saturated fat, % kcal	6.2	7.4-7.2	ALAP[e]
Monounsaturated fat, g	25.9	22.1-24.4	-
Monounsaturated fat, % kcal	11	10	-
Polyunsaturated fat, g	18.1	18-20.1	18.6[f]
Polyunsaturated fat, % kcal	7.8	8.0	5.5-11%[g]
Cholesterol, mg	128	236-256	ALAP[e]
Total dietary fiber, g	30	31-35	29[h]
Potassium, mg	4538	4154-4525	4700
Sodium, mg	1150*	1900-2110	1500
Magnesium, mg	498	386-425	320
Calcium, mg	1260	1333-1376	1000
Zinc, mg	12.1	17.3-15.4	11.0
Thiamin, mg	1.7	2.1-2.3	1.2
Riboflavin, mg	2.1	2.8-2.9	1.3
Niacin, mg	24.1	22.8-26.0	16.0
Vitamin B_6, mg	2.8	2.4-2.7	1.3
Vitamin B_{12}, µg	3.8	7.9-8.4	2.4
Vitamin C, mg	300	174-181	90
Vitamin E, mg AT[i]	11.6[i]	9.0-9.7[i]	15.0[i]

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[a]DASH = Dietary Approaches to Stop Hypertension.

[b]Only nutrients analyzed in the DASH studies are included. Nutrients not analyzed but for which RDAs or AIs have been established (IOM 1997; 1998; 2000b; 2001; 2002; 2004): chromium, copper, fluoride, iodine, iron, manganese, molybdenum, phosphorus, selenium, vitamin A, vitamin D, vitamin K, folate, pantothenic acid, biotin, and choline.

[c]In the DASH-Sodium trial, the average sodium intake was 1.5 g (65 mmol), as estimated by mean urinary excretion. The sodium intake of each participant was indexed to calorie level (0.9 to 1.8 g/d corresponding to 1600 to 3600 kcal/d) (Svetkey et al., 1999a).

[d]Average of recommended intake for young adult men and women; RDA = Recommended Dietary Allowance; AI = Adequate Intake; AMDR=Acceptable Macronutrient Distribution Range.

[e]As low as possible while consuming a nutritionally adequate diet.

[f]AI for men for n-3 fatty acids = 1.6 g; for n-6 fatty acids = 17 g; total = 18.6 g.

[g]n-3 fatty acids = 0.5-1.0 % of kcal; n-6 fatty acids = 5-10% of kcal.

[h]Amount listed is based on 14 g dietary fiber/1000 kcal.

[i]Vitamin E RDA is 15 mg d-α-tocopherol (AT); 1 mg ≈ 1.2 mg d-α-tocopherol equivalents (ATE). DASH diet contains 14.0 mg ATE, converted here to mg AT for comparability with AI and the USDA food pattern.

*The DASH diet has been studied at several different sodium levels. The sodium level of 1150 mg corresponds to the target for the lowest level in the DASH Sodium trial based on a 2100 kcal eating pattern. The actual level provided, based on 24-hour urinary excretion, was 1500 mg (65 mmol).

Table D1-19. Comparison of Various Sources of Calcium, Considering Bioavailability

Foods	Serving size[1] (g)	Calcium content[2] (mg/serving)	Estimated absorption efficiency[3] (%)	Number of servings to equal 1 cup milk	Food amount to equal calcium in 1 cup milk		Reference
Foods without added calcium:							
Milk	240	300	32.1	1.0	1.0	cups	Nickel, 1996
Beans, pinto	86	44.7	26.7	8.1	4.1	cups	Weaver, 1993
Beans, red	172	40.5	24.4	9.7	9.7	cups	Weaver, 1993
Beans, white	110	113	21.8	3.9	2.0	cups	Weaver, 1993
Bok choy	85	79	53.8	2.3	1.2	cups	Heaney, 1993
Broccoli	71	35	61.3	4.5	2.3	cups	Heaney, 1993
Cheddar cheese	42	303	32.1	1.0	1.5	oz	Nickel, 1996
Cheese food	42	241	32.1	1.2	1.8	oz	Nickel, 1996
Chinese cabbage flower leaves	85	239	39.6	1.0	0.5	cups	Weaver, 1997
Chinese mustard green	85	212	40.2	1.1	0.6	cups	Weaver, 1997
Chinese spinach	85	347	8.36	3.3	1.7	cups	Weaver, 1997
Kale	85	61	49.3	3.2	1.6	cups	Heaney & Weaver, 1990
Spinach	85	115	5.1	6.3	3.2	cups	Heaney, 1988
Sugar cookies	15	3	91.9	34.9	35	cookies	Weaver, 1991
Sweet potatoes	164	44	22.2	9.8	4.9	cups	Weaver, 1997
Rhubarb	120	174	8.5	9.5	9.5	cups	Weaver, 1997
Whole wheat bread	28	20	82.0	5.8	5.8	slices	Weaver, 1991
Wheat bran cereal	28	20	38.0	12.8	12.8	oz	Weaver, 1991
Yogurt	240	300	32.1	1.0	1.0	cups	Nickel, 1993
Foods with added calcium:							
Tofu, calcium set	126	258	31.0	1.2	0.6	cups	Weaver, 1997
OJ with Ca citrate malate	240	300	36.3	0.9	0.9	cups	Heaney, 1990a
Soy milk w/tricalcium phosphate	240	300	24.0	1.3	1.3	cups	Heaney, 2000
Bread w/ calcium sulfate	17	300	43.0	0.7	1	thin slice	Martin, 2002

[1]Based on 1/2 cup serving size (~ 85 g for green leafy vegetables), except for milk and fruit punch (1 cup or 240 mL) and cheese (1.5 oz).
[2]Taken from Pennington (1989) and USDA (1989), averaged for beans and broccoli processed in different ways, except for the Chinese vegetables, which were taken from Heaney et al. (1993).
[3]Adjusted for load using the equation for milk (fractional absorption = 0.889-0.0964 in load) (Heaney et al., 1990), then adjusting for the ratio of calcium absorption of the test food relative to milk tested at the same load, the absorptive index.

Table D1-20. Nutrients* Provided by 3 Cups of 1% Milk

Nutrient	**Amount of nutrient**	**Amount of nutrient as percent of requirement for female ages 31–50**
Calcium	871 mg	87% AI
Vitamin D (in N. America)	380 IU	38% of target goal of 1000 IU
Vitamin A	425 mcg RAE	61% RDA
Phosphorous	695 mg	99% RDA
Protein	24.7	54% RDA
Potassium	1098 mg	28% AI
Magnesium	81 mg	25% RDA

*Nutrients provided if Daily Recommended Amounts from milk group (3-cup equivalents) are consumed as 3 cups of 1% milk.

Table D1-21. Difference Between Recommended Calcium Intakes and Calcium Provided by the Food Pattern if Milk Products are Excluded

Calorie level	Age/sex group	Milk group servings	Calcium in pattern without milk group mg	Calcium recommendation mg	Calcium difference mg
1000		2	179		
	M/F 2 to 3			500	321
1200		2	241		
	M/F 4 to 8			800	559
1400		2	290		
	M/F 4 to 8			800	510
1600		3	335		
	F 9 to 13			1300	965
	F 51 to 70			1200	865
1800		3	399		
	F 31-50			1000	665
	M 9 to 13			1300	901
	F 14-18			1300	901
2000		3	415		
	F19-30			1000	585
	M 51-70			1200	785
2200		3	457		
	M 31-50			1000	543
	M 14-18			1300	843
2400		3	490		
	M 19-30			1000	510
2600		3	543		
	M 19-30			1000	457
2800		3	588		
	M 14-18			1300	712
3000		3	603		
	M 19-30			1000	397
3200		3	604		
	M 14-18			1300	696

Table D1-22. Food Sources of Iron

Table D1-22a. Food sources of iron ranked by milligrams of iron per standard amount; also calories in the standard amount. (All are ≥ 10% of RDA for teen and adult females, which is 18 mg.)

Food, standard amount	Iron (mg)[1]	Calories
Clams, canned, drained, 3 ounces	23.8	126
Fortified ready-to-eat cereals (various), ¾ to 1⅓ cup	4.2 – 18.1	74 – 120
Oysters, eastern, wild, cooked, moist heat, 3 ounces	10.2	116
Organ meats (liver, giblets), various, cooked, 3 ounces	5.2 – 9.9	134 – 276
Fortifed instant cooked cereals (various), 1 packet	4.9 – 8.1	Varies
Turkey giblets, cooked, 3 ounces	6.6	169
Soybeans, mature, cooked, ½ cup	4.4	149
Pumpkin & squash seed kernels, roasted, 1 ounce	4.2	148
Sesame seeds, roasted and toasted, 1 ounce	4.2	160
White beans, canned, ½ cup	3.9	153
Blackstrap molasses, 1 tablespoon	3.5	47
Lentils, cooked, ½ cup	3.3	115
Spinach, cooked from fresh, ½ cup	3.2	21
Beef, chuck, blade roast, lean, cooked, 3 ounces	3.1	215
Beef, bottom round, lean, 0" fat, all grades, cooked, 3 ounces	2.9	173
Beef, top sirloin, lean, 0" fat, all grades, cooked, 3 ounces	2.9	162
Kidney beans, cooked, ½ cup	2.6	112
Sardines, canned in oil, drained, 3 ounces	2.5	177
Beef, rib, lean, ¼" fat, all grades, 3 ounces	2.4	195
Chickpeas, cooked, ½ cup	2.4	134
Duck, meat only, roasted, 3 ounces	2.3	171
Lamb, shoulder, arm, lean, ¼" fat, choice, cooked, 3 ounces	2.3	237
Navy beans, cooked, ½ cup	2.3	129
Prune juice, ¾ cup	2.3	136

Table D1-22b. Food sources of iron as consumed by Americans[2] (percent of total consumption, CSFII, 1994–1996)

Food	Percent of total[3]
Ready-to-eat cereal	16.9
Yeast bread	13.1
Beef	8.5
Cakes/cookies/quick breads/doughnuts	4.2
Pasta	3.7
Flour/baking ingredients	3.2
Dried beans/lentils	3.1
Poultry	3.0
Potatoes (white)	2.6
Hot breakfast cereal	2.4
Rice/cooked grains	2.4
Tomatoes	2.4
Fish/shellfish (excluding canned tuna)	2.0

Table D1-22 (cont.). Food sources of iron

Food, standard amount	Iron (mg)[1]	Calories
Shrimp, canned, 3 ounces	2.3	102
Cowpeas, cooked, ½ cup	2.2	100
Ground beef, 15% fat, cooked, 3 ounces	2.2	212
Lima beans, cooked, ½ cup	2.2	108
Soybeans, green, cooked, ½ cup	2.2	127
Tomato puree, ½ cup	2.2	48
Refried beans, ½ cup	2.1	118
Tomato paste, ¼ cup	2.0	54

[1]Source: ARS Nutrient Database for Standard Reference, Release 16-1. Mixed dishes and multiple preparations of the same food item have been omitted.

[2]Source: Cotton et al. 2004. Data are for persons age 19 years and older, day 1 intakes.

[3] Food groups (n = 8) contributing at least 1% in descending order: eggs, crackers/pretzels, meal replacements/protein supplements, tortillas/tacos, potato chips/corn chips/popcorn, orange/grapefruit juice, pancakes/waffles/French toast, and coffee.

Table D1-23. Serum 25-hydroxyvitamin D Values by Seasonal Subpopulation in the Contiguous United States

Latitude and season	Age (y)	n	Mean	<25 nmol/L		<37.5 nmol/L		<50 nmol/L		<62.5 nmol/L	
				%	95% CI	%	95% CI	%	95% CI	%	95% CI
(A) Winter/lower latitude subpopulation (November-March, median latitude 32°N, range 25°-41°N)											
Male	12-19	625	78.6	1[a]	0, 2.2	5	2.4, 8.0	13	7.7, 17.4	25	17, 32
	20-39	1289	69.1	2	1.1, 3.3	12	9.2, 15.0	26	21.1, 29.9	43	37, 49
	40-59	864	70.6	2[a]	0.6, 3.1	9	5.8, 11.9	22	16.6, 26.8	39	32, 46
	60-79	827	72.5	1	0.2, 2.2	7	4.4, 10.2	18	12.7, 22.3	38	31, 46
	80+	204	68.7	3[a]	0, 6.3	12	4.3, 18.8	26	14.7, 37.6	47	31, 62
Female	12-19	699	64.9	4	2.0, 5.9	12	7.8, 16.3	29	22.8, 34.5	47	39, 55
	20-39	1459	62.7	5	3.4, 6.4	19	15.6, 22.7	40	35.4, 44.2	55	50, 61
	40-59	959	61.6	3	1.8, 5.0	17	13.2, 21.7	39	33.2, 44.0	57	50, 63
	60-79	757	63.5	5	2.5, 6.6	15	10.9, 20.0	36	30.1, 42.0	52	45, 59
	80+	208	59.6	5	1.1, 9.7	18	8.5, 27.3	37	25.2, 48.4	56	42, 69
(B) Summer/higher latitude subpopulation (April-October, median latitude 39°N, range 25°-47°N)											
Male	12-19	741	89.5	<1[a]	—	2[a]	0.7, 3.0	8	5.2, 11.0	21	15.8, 25.4
	20-39	1621	85.3	<1[a]	—	3	1.8, 3.9	11	8.6, 13.1	24	20.1, 27.0
	40-59	1122	78.8	1	0.5, 1.7	5	3.2, 6.3	14	11.3, 17.3	29	24.6, 33.3
	60-79	1072	76.8	<1[a]	—	4	2.7, 5.7	14	11.2, 17.3	32	27.7, 37.0
	80+	349	69.5	1[a]	0, 2.5	7	4.0, 10.8	19	12.8, 24.9	37	28.9, 45.7
Female	12-19	844	80.5	<1[a]	—	6	3.4, 7.9	13	9.5, 17.0	28	22.4, 34.1
	20-39	1964	81.6	2	1.0, 2.4	8	5.9, 9.2	18	14.8, 20.3	30	26.1, 33.9
	40-59	1264	68.6	2	0.9, 2.7	10	7.9, 12.6	26	22.3, 30.3	45	40.1, 50.6
	60-79	1200	65.6	2	1.1, 3.1	10	7.8, 12.6	29	24.6, 33.0	49	43.5, 54.4
	80+	394	61.8	3[a]	0.8, 4.7	12	7.4, 16.6	34	26.7, 42.3	58	49.0, 67.9

CI = Confidence Interval
[a] May be unreliable
Source: Looker et al., 2002

Table D1-24. Food Sources of Vitamin D

Food item	μg Vitamin D	IU Vitamin D
Fish	5-15/100 g	200-600/100 g
Fortified milk	2.5/cup	100/cup
Vitamin D fortified juice	2.5/cup	100/cup
Vitamin D fortified cereals	1 - 1.5/cup	40 - 60/cup
Vitamin D fortified breakfast bars	2.5/bar	100/bar

Source: Raiten DJ and MF Picciano (co-chairs). Vitamin D and Health in the 21st Century: Bone and Beyond. A conference conducted by the National Institutes of Health in Bethesda, Maryland, on October 9–10, 2003. Accessed at *www.nichd.nih.gov/prip* on August 2, 2004.

Section 2: Energy

This section addresses five major questions related to physical activity and energy intake:

1. How is physical activity related to body weight and other nutrition-related aspects of health?
2. How much physical activity is needed to avoid weight regain in weight-reduced persons?
3. What are the optimal proportions of dietary fat and carbohydrate to maintain body mass index (BMI)[1] and to achieve long-term weight loss?
4. What is the relationship between the consumption of energy-dense foods and BMI?
5. What is the relationship between portion size and energy intake?

The search strategies used to find the scientific evidence related to Questions 1 through 5, are shown in Appendix G-3. Questions 1, 2, and 3 have been addressed by expert panels that have published evidence-based reviews. Table D2-1 lists the BMI ranges for underweight, normal weight, overweight, and obese individuals.

Table D2-1. BMI classifications

Classification	BMI (kg/m^2)
Underweight	<18.5
Normal	18.5–24.9
Overweight	25.0-29.9
Obesity	30.9–39.9
Extreme obesity	40.0+

(NIH/NHLBI Web site: *www.nhlbi.nih.gov*)

The Dietary Guidelines Advisory Committee (the Committee) conducted a literature search on three additional questions: "Is there a level of activity below which one cannot regulate weight?," "What is the relationship of breakfast consumption to BMI?," and "What is the evidence to support caloric compensation for liquids versus solid foods?" The search on the first question did not result in a sufficient body of evidence to address this topic in this report. The Committee decided that the literature on the latter two questions was not sufficient to make conclusive statements, and these questions are addressed at the end of this section as Unresolved Issues.

The Committee included a strong focus on physical activity and energy expenditure in part because overweight and obesity in the United States among adults and children (Flegal et al., 2002) have increased at an alarming rate. Among adults, the prevalence of obesity has doubled in the past two decades (31 percent of adults have a BMI $\geq$30) (Flegal et al., 2002). Overweight among children has more than doubled since 1980 (7 to 16.5 percent in 1999–2002), while overweight among adolescents has tripled (5 to 16 percent in 1999–2002) (Hedley et al., 2004; Ogden et al., 2002). Information on differences in the prevalence of obesity by racial/ethnic group appears in Part B, "Introduction."

A high prevalence of overweight and obesity is of great public health concern because excess body fat leads to a much higher risk for premature death and many serious disorders, including diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, stroke, gall bladder disease, respiratory dysfunction, gout, osteoarthritis, and certain kinds of cancers (NIH, NHLBI, 1998; Pi-Sunyer, 1993). A sedentary lifestyle poses risks for premature death; coronary artery disease; hypertension; type 2 diabetes; overweight and obesity; osteoporosis; certain types of cancer; anxiety; depression; decreased health-related quality of life; and decreased cardiorespiratory, metabolic, and musculoskeletal fitness (U.S. Department of Health and Human Services [HHS], 1996).

Question 1: How Is Physical Activity Related to Body Weight and Other Nutrition-Related Aspects of Health?

Conclusions

Regular physical activity is essential to the maintenance of a healthy weight and reduces the risk for the development of a number of chronic diseases. At least 30 minutes of moderate physical activity on most days provides important health benefits in adults. More than 30 minutes of moderate to vigorous physical activity on most days provides added health benefits.

[1] **Body Mass Index** or BMI is a tool for indicating weight status in adults. It is a measure of weight for height. BMI = (Weight in Pounds/[Height in Inches]^2) x 703 (CDC Web site: *www.cdc.gov/nccdphp/dnpa/bmi/bmi-adult-formula.htm*).

Many adults may need up to 60 minutes of moderate to vigorous physical activity on most days to prevent unhealthy weight gain.

Vigorous physical activity (e.g., jogging or other aerobic exercise) provides greater benefits for physical fitness than does moderate physical activity and burns calories more rapidly per unit of time.

Exercise that loads the skeleton has potential to reduce the risk of osteoporosis by increasing peak bone mass during growth, maintaining peak bone mass during adulthood, and reducing the rate of bone loss during aging.

Resistance exercise training increases muscular strength and endurance and maintains or increases lean body weight. These benefits are seen in adolescents, adults, and older adults who perform 8 to 10 resistance exercises 2 or more days per week.

Children and adolescents need at least 60 minutes of moderate to vigorous physical activity on most days for maintenance of good health and fitness and for healthy weight during growth. Reducing sedentary behaviors, including television- and video-viewing time, appears to be an effective way to treat and prevent overweight among children and adolescents.

Rationale

Adults

These conclusions are based on the Committee's systematic review of 36 longitudinal studies and 2 intervention studies addressing this issue (see Appendix G-3).

Physical Activity and the Prevention of Excessive Weight Gain—Overweight and obesity result from inadequate physical activity and/or excess calorie consumption. A sedentary lifestyle is a lifestyle characterized by little or no physical activity. Data suggest that physical activity levels are low for most Americans. For example, beyond the light activity of day-to-day living, in 2002, 38 percent of adult Americans engaged in no leisure-time physical activity (NHIS, 2002).

Thirty of 36 longitudinal studies (Appendix G-3) show an inverse relationship between physical activity and overweight status. Of six of the remaining longitudinal studies, five show no significant relationship between physical activity and weight status, and one (Bild et al., 1996) found an increase in body weight associated with a large amount of vigorous physical activity at baseline.[2]

The role of physical activity in the prevention of weight gain was studied in a systematic review of 16 observational studies (Fogelholm and Kukkonen-Harjula, 2000). In a separate systematic review, Erlichman and colleagues (2002) included studies only if they could estimate the Physical Activity Level (PAL) equivalent of the specified activities as a means of standardizing their approach. An expert panel convened by the International Association for the Study of Obesity (IASO)[3] reviewed the evidence presented by Erlichman et al. (2002). That panel concluded that approximately 45 to 60 minutes of moderate intensity daily physical activity is needed to prevent the transition from a healthy weight to overweight or from overweight to obesity (Saris et al., 2003).[4] Table D2-2 gives examples of moderate physical activities.

Based on an extensive compilation of cross-sectional doubly-labeled water studies in humans, the Institute of Medicine (IOM)(2002) reported that two-thirds of adults who maintain energy balance expended an equivalent amount of energy to that which would be expended by engaging in 60 minutes per day at moderate intensity. Thus, it appears that many adults

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[2] Vigorous physical activity, such as running 5 miles per hour, is any activity that burns more than 7 kcal per min or the equivalent of 6 or more metabolic equivalents (METs) and results in achieving 74 to 88 percent of a person's peak heart rate.

[3] The International Association for the Study of Obesity is a professional organization concerned with obesity that works in more than 50 countries around the world. Its membership is drawn from national associations of clinicians, scientists, and allied health professionals. As a nongovernmental organization (NGO), IASO collaborates with the World Health Organization and other NGOs including the International Diabetes Federation, the World Hypertension League, the World Heart Federation, the International Union of Nutritional Sciences, the International Pediatric Association, and the International Federation for the Surgery of Obesity.

[4] Moderate physical activity, such as walking 3.5 miles per hour, is any activity that burns 3.5 to 7 kcal per minute or the equivalent of 3 to 6 METs and results in achieving 60 to 73 percent of the person's peak heart rate.

Table D2-2. Examples of Moderate Physical Activities[1] and Corresponding METS and Kcals Burned/Hour for a 154-lb Person

Moderate PA	**Estimated METs[2]**	**kcals burned/hr[3]**
Hiking	4.9	367
Light gardening/yard work	4.5	331
Dancing	4.5	331
Golf (walking and carrying clubs)	4.5	331
Bicycling (<10 mph)	4.0	294
Walking (3.5 mph)	3.8	279
Weight lifting (general light workout)	3.0	220
Stretching	2.5	184

Conversion: (METs x 3.5 [body weight in lb/2.2])]/200 = kcal/min.

[1]**Moderate physical activities**—any activity that burns 3.5 to 7 calories per minute (kcal/min) or the equivalent of 3 to 6 metabolic equivalents (METs) (CDC) and results in achieving 60 to 73 percent of the peak heart rate (ASCM). Other examples include mowing the lawn or swimming. A person should feel some exertion but should be able to carry on a conversation comfortably during the activity (CDC Web site *www.cdc.gov/nccdphp/dnpa/physical/terms/index.htm*).

[2] METs—the resting metabolic rate (approximately the amount of energy it takes to sit quietly).

[3] For a 154-lb individual, calories burned per hour will be higher for persons who weigh more than 154 lbs and lower for persons who weigh less than 154 lbs.

need up to 60 minutes per day of at least moderate intensity physical activity to prevent unhealthy weight gain (IARC,[5] 2002; IOM,[6] 2002; Saris et al., 2003).

Physical Activity and Physical Fitness—Physical fitness is a multicomponent trait related to the ability to perform physical activity. The components of physical fitness include cardiorespiratory endurance, muscular strength and endurance, and flexibility. Regular participation in physical activity maintains or increases physical fitness. However, the effects of activity on fitness are specific to the types of physical activity performed. Regular participation in sustained large-muscle activity (e.g., brisk walking, jogging, cycling, swimming) increases or maintains cardiorespiratory fitness. Resistance exercise (e.g., weight lifting, callisthenic exercises) increases muscular strength and endurance, and stretching exercises promote maintenance of joint flexibility. Maintenance of good physical fitness enables one to meet the physical demands of work and leisure comfortably. Compared with their low-fit counterparts, persons with higher levels of physical fitness are at lower risk of developing chronic disease (Blair et al., 1989, 1995).

Physical Activity and Other Aspects of Health—The consensus public health recommendation for physical activity in adults—at least 30 minutes of at least moderate intensity physical activity daily—was developed with a primary focus on the chronic disease risk reduction and fitness enhancement effects (HHS, 1996; Pate et al., 1995). Most authorities also acknowledge that vigorous physical activity for at least 20 minutes on at least 3 days per week is another appropriate way to perform physical activity for health and fitness (ACSM,[7] 1998).

[5] The International Agency for Research on Cancer (IARC) is part of the World Health Organization. IARC's mission is to coordinate and conduct research on the causes of human cancer, the mechanisms of carcinogenesis, and to develop scientific strategies for cancer control. The Agency is involved in both epidemiological and laboratory research and disseminates scientific information through publications, meetings, courses, and fellowships.

[6] The Institute of Medicine is a component of the National Academies. The objective in all their work is to improve decisionmaking by identifying and synthesizing relevant evidence to inform the deliberative process. The Institute provides unbiased, evidence-based, and authoritative information and advice concerning health and science policy to policymakers, professionals, leaders in every sector of society, and the public at large.

[7] Position Stands are official statements of the American College of Sports Medicine (ACSM) on topics related to sports medicine and exercise science. Position Stands are based on solid research and scientific data and serve as a valued resource for professional organizations and

Examples of vigorous physical activities appear in Table D2-3. The health benefits of regular physical activity include the reduction of risk of a number of chronic conditions and diseases that relate to diet as well. Among these are high blood pressure, stroke, coronary artery disease, type 2 diabetes, colon cancer, and osteoporosis (Pate et al., 1995; Shephard, 2001).

Decreases in blood pressure and the prevention of stroke seem best achieved by a moderate rather than a high intensity of physical activity (Shephard, 2001). Vigorous intensity seems necessary to augment bone health (HHS, 1996; Pate et al., 1995). Although some health benefits are dependent on the intensity of physical activity (i.e., moderate or vigorous), most aspects of metabolic health depend on the total volume of activity. That is, vigorous physical activity can have greater effects than moderate physical activity of the same duration, but it is the combination of intensity (moderate or vigorous) and the duration of this activity that affects both caloric expenditure and overall health (Kesaniemi et al., 2001; Shephard, 2001).

Physical inactivity is an *independent* risk factor for atherosclerotic cardiovascular disease, type 2 diabetes, colon cancer, and other chronic diseases (American Heart Association, 1992; HHS, 1996). Increases in physical activity are associated with reduced risk of chronic disease and mortality from all causes (Blair et al., 1995; Paffenbarger et al., 1993), and this effect is mediated by numerous physiological adaptations, including improvements in weight status and body composition. However, the health effects of physical activity and physical fitness are not explained primarily by its effect on body weight. Overweight persons derive important health benefits from maintaining good levels of physical activity and physical fitness (Lee et al., 1999).

Resistance Exercise Training—Resistance exercise (e.g., weight training, using weight machines, callisthenic exercises, and resistance band activities) increases muscular strength and maintains or increases lean muscle mass in persons of all ages (ACSM, 2002). In older adults, resistance exercise assists in balance and locomotion, thereby reducing the risk of falling (Evans, 1999). The health benefits of resistance exercise accrue to those who perform, on 2 or more days per week, 1 or more sets of 8 to 10 exercises that condition the major muscle groups.

Exercise and Bone Health—Building maximal peak bone mass during growth and minimizing the loss of bone during one's later years are strategies for reducing the risk of fracture. Rapid accrual of bone mass occurs during puberty (Bailey et al., 1999) and continues throughout adolescence and into young adulthood (Heaney et al., 2000). Approximately 20 to 50 percent of the variation in bone mass is thought to be modified by lifestyle choices, including physical activity and nutrition.

Bone adapts to the loads applied to it (Frost, 1990; Rubin and Lanyon, 1985). The skeletal response to exercise is greatest in people who are least active. Loading can occur by gravitational forces and muscle pull. A systematic review of weight-bearing physical activity intervention studies in children and adolescents showed a positive effect on bone mass (French et al., 2000). Pediatric studies relating exercise and bone gain reviewed by the Committee are summarized in Appendix G-3. Thirteen of 15 physical activity intervention trials in children show a positive effect ofexercise intervention on one or more bone sites. Exercise interventions have greater impact on bone mass if initiated during prepubertal years than later in life. Perhaps even more importantly, in children exercise can lead to changes in bone geometry that can confer greater strength (Bass et al., 2001; Haapasalo et al., 1996; Specker and Binkley, 2003).

Weight-bearing exercise also appears to be important in preserving peak bone mass in adulthood. Relatively short-term (<2 year) intervention studies and epidemiological studies show mixed results (Singh, 2004). All seven meta analyses of controlled trials of exercise and bone in pre- and postmenopausal women show increases in bone mineral density at the lumbar spine of approximately 1 to 1.5 percent per year with aerobic and resistance training (Berard et al., 1997; Kelley et al., 2001; Kelley 1998a, 1998b, 1998c; Wallace and Cummings, 2000; Wolff et al., 1999). (See Appendix G-3.)

A physically active lifestyle that includes regular participation in weight-bearing exercise is beneficial to weight management, fitness, and bone health. Hip fracture incidence was 30 to 50 percent lower in adults with a history of daily physical activity than in sedentary individuals (Coupland et al., 1993; Cummings et al., 1995; Farmer et al., 1989). For example, in 9,704 women over age 65 participating

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governmental agencies. Position Stands are first published in the College's scientific journal, *Medicine & Science in Sports & Exercise.*

Table D2-3. Examples of Vigorous Physical Activities[1] and Corresponding METS and Kcals Burned/Hour for a 154-lb Person

Vigorous PA	Estimated METs[2]	kcals burned/hr[3]
Running/Jogging (5 mph)	8.0	588
Bicycling (>10 mph)	8.0	588
Swimming (slow freestyle laps)	6.9	514
Aerobics	6.5	478
Walking (4.5 mph)	6.3	464
Heavy yard work (chopping wood)	6.0	441
Weight lifting (vigorous effort)	6.0	441
Basketball (vigorous)	6.0	441

Conversion: (METs x 3.5 [body weight in lb/2.2])/200 = kcal/min.

[1]**Vigorous physical activities**—any activity that burns more than 7 kcal/ min or the equivalent of 6 or more metabolic equivalents (METs) (CDC) and results in achieving 74 to 88 percent of your peak heart rate (ASCM). Other examples include mowing the lawn with a nonmotorized pushmower and participating in high-impact aerobic dancing. Vigorous-intensity physical activity is intense enough to represent a substantial challenge to an individual and results in a significant increase in heart and breathing rate (CDC Web site *www.cdc.gov/nccdphp/dnpa/physical/terms/index.htm*).

[2] METs—the resting metabolic rate (approximately the amount of energy it takes to sit quietly).

[3] For a 154-lb individual, calories burned per hour will be higher for persons who weight more than 154 lbs and lower for persons who weigh less.

in the *Study of Osteoporosis Fracture*, the incidence of fracture over 7.6 years was 27 percent lower with low-intensity activity and 45 percent lower with moderate physical activity (Gregg et al., 1998).

Specific recommendations for the type, frequency, intensity, and duration of exercise should be individualized with respect to lifestage and health (Singh, 2004). Because the effects of loading are site specific and load dependent (Kerr et al., 1996), the most effective types of physical activity for bone health are weight-bearing exercises such as jogging, walking, aerobics, stair climbing, and strength training (Kohrt et al., 1997; Nelson et al., 1991; Snow-Harter et al., 1992). Extreme exercise that leads to growth plate injury or estrogen-deficiency associated with amenorrhea is detrimental to bone (Forwood and Burr, 1993).

Children

Two types of evidence are available related to physical activity and weight status in children: considerations of amounts of physical activity consistent with a healthy body weight and studies of sedentary activity (mainly television viewing).

Increasing Physical Activity—Although the relevant scientific literature is limited, most expert panels have come to consensus that children and youth need at least 60 minutes of moderate to vigorous physical activity per day on most days of the week to help promote healthy growth and development and to help avoid unhealthy weight gain (Cavill et al., 2001). This recommendation considers the increasing prevalence of overweight among children and their current physical activity levels: most children and youth already engage in 30 minutes of physical activity daily, but many do not meet a 60-minute standard (Biddle et al., 1998; Kimm et al., 2002).

Television Viewing—The average child or adolescent watches nearly 3 hours of television per day, not including time spent watching videotapes or playing video games (Nielsen Media Research, 1998). A 1999 study of a large nationally representative sample found that children and adolescents age 2 to 18 spend an average of 5 hours and 29 minutes per day with various media combined (Roberts et al., 1999). The prevalence of overweight has been shown consistently to be directly related to the amount of time children and adolescents watch television (Andersen et al., 1998; Berkey et al., 2000; Deheeger et al., 1997; Dietz and

Gortmaker, 1985; DuRant et al., 1994; Gortmaker et al., 1996; Grund et al., 2001; Guillaume et al., 1997; Hanley et al., 2000; Hernandez et al., 1999; Maffeis et al., 1998; Muller et al., 1999; Ross and Pate, 1987; Sallis et al., 1995); and reductions in television and video viewing time appear to be effective strategies to treat and prevent overweight. One school-based study demonstrated a 2 percent decrease in the prevalence of overweight over the course of 2 school years as a result of a curriculum that focused on reduced television viewing time (Gortmaker et al., 1999). A second school-based study demonstrated reduced rates of weight gain in children who reduced television time (Robinson, 1999). The American Academy of Pediatrics recommends limiting television and video viewing to a maximum of 2 hours per day as a strategy to prevent overweight in children (AAP, 2003).

Pregnancy

Epidemiologic data suggest that physical activity may be beneficial in the primary prevention of gestational diabetes, particularly in pregnant women with a prepregnancy BMI > 33 (ACOG, 2002; Dempsey et al., 2004; Dye et al., 1997). Rössner (1999) reported smaller increase in skinfold measurements in pregnant women who exercised, indicating less gain in body fat by those who exercised than by those who did not. The physiologic and morphologic changes of pregnancy may interfere with a woman's ability to engage safely in some forms of physical activity. Activities with a high risk of falling or of abdominal trauma should be avoided during pregnancy. In the absence of either medical or obstetric complications, 30 minutes or more of moderate physical activity per day on most, if not all, days of the week is recommended for pregnant women (ACOG, 2002).

Lactation

Dewey et al. (1991) have shown that the level of physical activity of the nursing mother does not affect lactation. Neither acute nor regular exercise has adverse effects on a mother's ability to successfully breastfeed (Larson-Meyer, 2002).

Older Adulthood

Participation in a regular program of physical activity is an effective method to reduce a number of declines in function that are associated with aging and can help in the management of weight and constipation and the prevention of osteoporosis. Endurance training can help maintain and improve various aspects of cardiovascular function. Strength training helps offset the loss in muscle mass and strength typically associated with aging. Even octo- and nonagenarians have demonstrated the ability to adapt to both endurance and strength training. Strength training can improve bone health, increase muscle mass, and improve postural stability thus reducing the risk of falling and associated injuries and fractures (ACSM, 1998).

Question 2: How Much Physical Activity Is Needed to Avoid Weight Regain in Weight-Reduced Persons?

Conclusions

Although the contribution of physical activity to weight loss usually is modest, acquiring a routine of regular physical activity will help an adult to maintain a stable body weight after successful weight loss. The amount of physical activity that weight-reduced adults need to avoid weight regain is estimated to be from 60 to 90 minutes daily at moderate intensity.

Rationale

This conclusion is based on the Committee's review of cross-sectional data from the National Weight Control Registry, two metabolic studies using the doubly-labeled water (DLW) technique, and a published extensive systematic review of observational studies and randomized clinical interventions. Overall, studies have shown that individuals who follow a regular regimen of physical activity after they lose weight are much more likely to maintain their lower weight than those who rely only on diet control, as described below (see Appendix G-3 for a summary of relevant studies).

Cross-sectional data from the National Weight Control Registry show that individuals who have maintained a weight loss of approximately 30 kg for about 6 years participate in a large amount of leisure-time physical activity (2,545 kcal per week of physical activity for women and 3,293 kcal per week for men) (McGuire et al., 1999). This amount of physical activity is comparable to about 60 to 90 minutes per day of moderate intensity physical activity, such as brisk walking (Wing and Hill, 2001). The reported calorie expenditure of the weight maintainers was 450 kcal per day more than that of the persons who had regained the weight they had lost ($p = 0.02$), showing that the inclusion of a physical activity regimen helps to maintain reduced weight.

Metabolic studies using the DLW technique can provide useful estimates of an individual's level of

physical activity. Using this approach to estimate the physical activity levels of a group of 32 women after weight loss, Schoeller and colleagues (1997) reported that weight was maintained for 1 year when the subjects averaged the equivalent of 80 minutes of moderate activity every day. Another study using DLW to estimate the physical activity level reported similar results: the weight-reduced subjects maintained their weight for 1 year when they engaged in moderate activity for 77 minutes per day, but those who engaged in much less physical activity regained weight (Weinsier et al., 2002). The results of these studies are consistent with the findings from the National Weight Control Registry reported above.

The role of physical activity in the prevention of weight regain was studied in a systematic review both of observational studies and randomized clinical interventions (Fogelholm and Kukkonen-Harjula, 2000). Nineteen studies with a nonrandomized weight reduction phase and an observational follow-up were reviewed. Of these, 16 studies found an inverse relationship between physical activity and weight regain, and 3 found no significant relationship. The design of several of these studies (Ewbank et al., 1995; Hartman et al., 1993; Schoeller et al., 1997) allowed estimation of the difference in energy expenditure of the low- and high-exercise groups. In particular, the difference ranged from 1,300 to 2,000 kcal per week. The low-activity group gained approximately 5 to 8 kg more per year than did the high-activity group. Fogelholm and Kukkonen-Harjula (2000) also reviewed reports of three interventions involving physical activity during the weight maintenance phase. The results were inconsistent. Leermakers et al. (1999) reported that the exercise group gained *more* weight than the weight-focused group. Fogelholm et al. (2000) found that the moderate walking group gained less weight than the control group, but the heavy walking group did not differ from the control group. Perri et al. (1989) reported that the weight regain of the extended treatment group did not differ from that of the standard group at 20 weeks, but the extended treatment group showed significantly greater mean weight loss at 40 and 72 weeks. Since the weekly amount of prescribed physical activity in these trials varied from 80 to 300 minutes per week (about 11 to 43 minutes per day), the amount of physical activity may have been too small to have a statistically significant effect on weight maintenance. When looking at the full body of evidence, Fogelholm and Kukkonen-Harjula (2000) concluded that the physical activity equivalent of 1,500 to 2,000 kcals per week is associated with weight maintenance. This range of calories is equivalent to approximately 60 to 90 minutes of moderate physical activity per day.

Finally, an expert panel convened by the International Association for the Study of Obesity reviewed the existing studies, including the systematic review by Fogelholm and Kukkonen-Harjula (2000). The panel concluded, "there is compelling evidence that prevention of weight regain in formerly obese individuals requires 60 to 90 minutes of moderate intensity activity or lesser amounts of vigorous intensity activity" (Saris et al., 2003).

Thus, a broad range of evidence supports a recommendation that weight-reduced persons take part in 60 to 90 minutes of moderate physical activity daily to maintain their lower body weight and avoid regain of weight. This is a longer duration of physical activity than is needed by never-obese persons to avoid weight gain.

Question 3: What Are the Optimal Proportions of Dietary Fat and Carbohydrate to Maintain BMI and to Achieve Long-term Weight Loss?

Conclusions

Weight maintenance depends on a balance of energy intake and energy expenditure, regardless of the proportions of fat, carbohydrate, and protein in the diet. Weight loss occurs when energy intake is less than energy expenditure, also regardless of the proportions of fat, carbohydrate, and protein in the diet. For adults, well-planned weight loss diets that are consistent with the Accepted Macronutrient Distribution Ranges (IOM, 2002) for fat, carbohydrate, and protein can be safe and efficacious over the long term. The recommended ranges for fat calories (20 to 35 percent of total calories), carbohydrate calories (45 to 65 percent of total calories), and protein calories (10 to 35 percent of total calories) provide sufficient flexibility to accommodate weight maintenance for a wide variety of body sizes and food preferences.

Rationale

These conclusions are based on the Committee's consideration of short- and long-term intervention studies reviewed by an expert IOM Committee (IOM, 2002). Additionally, this Committee conducted a

Table D2-4. Decreased Fat Intake and Body Weight Change in Nonobese or Moderately Obese Subjects (IOM Table 11.1 [IOM, 2002])

Reference	Study Design	Dietary Fat (percent of energy)	Weight Change (kg)		Comments
Short-term studies (< 1 year)					
Boyar et al., 1988	19 women 6-mo intervention Ad libitum diet	34 → 21	–5.1		Decreased fat intake associated with decreased energy intake
Buzzard et al., 1990	29 postmenopausal women 3-mo parallel Ad libitum diet	38 → 23 39 → 35	–2.8 –1.3		Decreased fat intake associated with decreased energy intake
Bloemberg et al., 1991	80 men 26-wk parallel Ad libitum diet	39 → 34 38 → 37	–0.94 +0.06		
Kendall et al., 1991	13 women 11-wk crossover Controlled diet	20–25 35–40	–2.54 –1.26		Decreased fat intake associated with decreased energy intake Low-fat diet hypocaloric
Leibel et al., 1992	13 men and women 15- to 56-d intervention Controlled diet	0, 40, or 70	No significant changes in body weight		Isocaloric diets
Westerterp et al., 1996	217 men and women 6-mo parallel Ad libitum diet	35 → 33 36 → 41	+0.3 +1.1		
Raben et al., 1997	11 women 14-d crossover Ad libitum	46 → 28	–0.7		Decreased fat intake associated with decreased energy intake
Gerhard et al., 2000	22 women 4-wk crossover Controlled diet	20 40	–1.1 –0.3		Low-fat diet hypocaloric
Saris et al., 2000	398 men and women 6-mo parallel Ad libitum diet	36 → 26 36 → 28 36 → 37	–0.9 –1.8 +0.8		Decreased fat intake associated with decreased energy intake
Long-term studies (≥ 1 year)					
Lee-Han et al., 1988	57 women 1-year parallel Ad libitum diet	 36 → 23 → 26 36 → 34 → 36	6 mo –1.16 +0.07	12 mo –0.93 +0.62	Decreased fat intake associated with decreased energy intake
Boyd et al., 1990	206 women 1-year parallel Ad libitum diet	37 → 21 37 → 35	–1.0 0		

Table D2-4 (cont.). Decreased Fat Intake and Body Weight Change in Nonobese or Moderately Obese Subjects (IOM Table 11.1 [IOM, 2002])

Reference	Study Design	Dietary Fat (percent of energy)	Weight Change (kg)	Comments
Sheppard et al., 1991	276 women 1- and 2-year parallel Ad libitum diet	0 to 1 y 39 → 22 39 → 37 1 y to 2 y 22 → 23	 –3.0 –0.4 + 1.1	Decreased fat intake associated with decreased energy intake
Baer, 1993	70 men 1-year parallel Ad libitum diet	38 → 31 37 → 36	–5.0 +1.0	Decreased fat intake associated with decreased energy intake
Kasim et al., 1993	72 women 1-year parallel Ad libitum diet	36 → 18 36 → 34	–3.4 –0.8	Decreased fat intake associated with decreased energy intake
Black et al., 1994	76 men and women 2-year parallel Ad libitum diet	40 → 21 39 → 39	–2.0 –1.0	
Knopp et al., 1997	137 men 1-year parallel Ad libitum diet	36 → 27 35 → 22	–2.9 –2.9	
Stefanick et al., 1998	177 postmenopausal women and 190 men 1-year parallel Ad libitum diet	Women Men 23 22 28 30	Women Men –2.7 –2.8 +0.8 +0.5	Decreased fat intake associated with decreased energy intake
Kasim-Karakas et al., 2000	54 postmenopausal women 1-year intervention Controlled diet 4 mo Ad libitum diet 8 mo	 34 → 14 → 12	4 mo 12 mo –1.3 –5.9	

systematic review of the scientific literature published since 1999 (after the conclusion of the IOM review). The search covered intervention and longitudinal studies, and the results included 12 clinical trials and 3 observational studies. (See Table D2-4 for intervention studies up to the year 2000; and see Appendix G-3 for a summary of relevant results of the search of publications after 1999.)

Weight Reduction

Background Information—A sound long-term weight loss plan includes a reduction of caloric intake, the intake of recommended amounts of nutrients, and increased physical activity. Lifestyle change in diet and physical activity is the best first choice for weight loss. (See "Supplemental Information—Scientific Support for Weight Loss and Weight Management Recommendations" below for Federal guidelines for weight reduction.)

Diets balanced in macronutrients have traditionally been recommended for weight loss (American Heart Association, 2001; Frantz et al., 2002; NIH, NHLBI, 1998; St. Jeor et al., 2001). Numerous studies attest to their efficacy (Diabetes Prevention Program Research Group, 2002; Tuomilehto et al., 2001; Wing and Hill, 2001). However, many persons are going on very-low carbohydrate or very-low fat diets. These popular weight-loss diets encompass a very wide range of carbohydrate/fat ratios, ranging from less than 10 percent of calories from fat to more than 50 percent of calories from fat. They have not been tested adequately over the long-term and are best followed only for short periods of time.

Low-Carbohydrate, High-Fat Diets—The propounded theory behind low-carbohydrate, high-fat diets is that a drastically reduced carbohydrate intake will lower insulin levels, allow uninhibited lipolysis, increase fat oxidation, initiate ketone production, and decrease appetite (Atkins, 1999). Another expectation of diets with an extremely low ratio of carbohydrate to fat is that they will facilitate compliance and increase water losses. Five randomized controlled trials (Brehm et al., 2003; Fleming, 2002; Foster et al., 2003; Samaha et al., 2003; Westman et al., 2002) recently have compared weight loss after 6 months to 1 year on diets that have low carbohydrate-to-fat ratios with weight loss on more balanced diets. The low-carbohydrate diets initially provided less than 20 to 30 g of carbohydrate per day (followed by 40 to 60 g of carbohydrate per day after the first 2 weeks in both Brehm et al. (2003) and Foster et al. (2003)). Control diets provided 60 percent of calories from carbohydrate, 25 to 30 percent of calories from fat, and 15 percent of calories from protein (Brehm et al., 2003; Fleming, 2002; Foster et al., 2003; Samaha et al., 2003; Westman et al., 2002). All studies found that the low-carbohydrate diets produced greater initial weight loss, but the difference was modest. For example, Foster and colleagues (2003) reported that mean weight loss at 6 months was 7.0 percent below baseline for those on the low-carbohydrate diet compared with 3.2 percent below baseline for those on the control diet. At 18 months, however, there was no statistically significant difference in weight loss. Some of the early weight loss on a low-carbohydrate diet is due to water loss (Yang and Van Itallie, 1976; Bortz et al., 1967). Whether the remaining difference in initial weight loss is due to a lower energy intake, a larger energy expenditure, or a combination of the two is not known. In any case, differences in weight loss tend to diminish, and by 12 to 18 months no real difference remains.

The long-term safety of any diet needs to be considered. Unfortunately, only short-term data (6 to 12 months) are available for these diets. Within this period of follow-up, no evidence of serious adverse effects has been published. However, the diets require that dietary supplements be taken regularly because the diets are low in vitamins E, A, thiamin, B_6, and folate; calcium; magnesium; iron; potassium; and dietary fiber (Freedman et al., 2001). Very-low-carbohydrate diets often include a high percentage of protein along with the high percentage of fat. Usually, this includes large amounts of animal protein, which adds substantially to the saturated fat and cholesterol intake. A recent study has cautioned that such diets also can lead to a high urinary calcium loss and kidney stones (Reddy et al., 2002). Uric acid production is increased and may lead to elevated blood uric acid concentrations. There are very few long-term trials of high-protein-weight loss diets. Skov et al. (1999) showed a greater weight loss with a higher protein diet (25 percent of total energy) than with a lower protein diet (12 percent of total energy) (loss of 8.9 kg and 5.1 kg, respectively) over 6 months. Another study, 10 weeks long, showed no difference in the body composition, cholesterol, triglycerides, uric acid, percent body fat, or nutrient intake in sedentary, overweight women following 1,200 calorie diets with varying macronutrient distributions (Alford et al., 1990). Interestingly, blood lipid values in the various studies of high-fat diets were found to have improved at least as much as in the lower-fat control diets (Foster et al., 2003; Samaha et al., 2003). Larosa et al. (1980), however, reported an increase in serum low-density lipoprotein (LDL) cholesterol on a high-protein/high-fat diet.

The concern regarding the long-term safety of high-fat, low-carbohydrate diets is warranted given that (1) they have a high saturated fat, high cholesterol, and low fiber content;[8] (2) they result in a very low intake of fruits, vegetables, and grains (which could lead to deficiencies in essential vitamins, minerals, and fibers over the long-term); and (3) they originally were designed for short-term use during a weight loss period and have not been evaluated long-term.

High-Carbohydrate, Low-Fat Diets—A diet with a high-carbohydrate/fat ratio (that is, a very low-fat diet) has been popularized by Ornish (1990) and Pritikin (1988). This diet suggests decreasing fat intake to about 10 percent of calories, keeping protein at 15 percent of calories, and eating about 75 percent of calories as carbohydrates. The high-carbohydrate content is compatible with achieving more than the recommended intake of fruits, vegetables, and fiber. However, the very-low fat content may increase the risk of essential fatty acid deficiency (IOM, 2002) and may reduce the bioavailability of some fat-soluble vitamins (IOM, 2002; Roodenburg et al., 2000). In a weight-loss study Mueller-Cunningham et al. (2003) prescribed a diet with less than 15 percent of total calories from fat and reported a decrease in the intakes of vitamin E (as α-tocopherol) and of n-3 fatty acids. Freedman et al. (2001) described these high-carbohydrate/low-fat diets as being low not only in vitamin E, but also in vitamin

[8] The negative consequences of high saturated fat and cholesterol intake is discussed in Part D, Section 4 of this report. The negative consequences of low fiber intake is discussed in Part D, Section 5 of this report.

B_{12} and zinc. The other negative consequence of a low-fat diet is that it usually is a high-carbohydrate diet, which can lead to increased levels of triglycerides (see Part D, Section 4, "Fats").

Weight Maintenance

For weight maintenance, the desirable diet is one that prevents weight gain, meets nutrient needs, and can be consumed for a long time without adverse effects. One of the questions is how much fat should be in such a diet. The majority of observational studies and surveys support an association between dietary fat intake and BMI. Bray and Popkin (1998) summarized data from a variety of populations in more than 20 countries and reported an association between greater fat intake and higher BMI. However, Willett (1998) points out that this relationship is not consistent across countries and that the effect of fat intake on BMI is rather minor.

For adults, the Acceptable Macronutrient Distribution Ranges (AMDRs) for fat, protein, and carbohydrate are estimated to be 20 to 35 percent, 10 to 35 percent, and 45 to 65 percent of energy, respectively (IOM, 2002). The upper range for fat—35 percent of total calories—is based on the increased risk of overconsuming calories and of obesity with fat intakes above that range (Astrup et al., 2000; Saris et al., 2000; Shepard et al., 2001; Tremblay et al., 1991). Thus, diets with very-low carbohydrate to fat ratios (i.e., diets high in fat) may not be desirable for weight maintenance. The lower limit of fat recommended 20 percent of calories and aims at avoiding (1) fatty acid deficiency when fat intake is too low (Mueller-Cunningham et al., 2003), and (2) excess carbohydrate intake, which may have adverse effects on the blood lipid profile (see Part D, Section 4, "Fats").

Both the low-carbohydrate diet and the low-fat diet limit the variety of foods that can be eaten and, therefore, may be difficult to follow long term (Foster et al., 2003). This probably explains the extremely high dropout rates in studies of these diets. There is insufficient evidence to make recommendations for or against the use of these diets for weight loss, but there is great concern about their long-term use for weight maintenance (Bravata et al., 2003).

Although both low-fat diets and low-carbohydrate diets have been shown to result in weight reduction if followed, the maintenance of a reduced weight ultimately will depend on a change in lifestyle from the one that resulted in the need for weight reduction to one that meets nutrient needs while maintaining a balance between energy consumption and energy expenditure (Freedman et al., 2001).

Special Groups

Pregnant Women—Weight gain rather than weight maintenance or weight loss is indicated for pregnant women. The IOM has recommended the following gains in weight for women according to their prepregnancy BMI: (1) underweight (BMI < 19.8), 28 to 40 pounds; (2) normal weight (BMI 19.8–26.0), 25 to 35 pounds; (3) overweight (BMI 26–29), 15 to 25 pounds; (4) obese (BMI > 29), at least 15 pounds (IOM, 1990). For the obese woman, the amount of weight gain should not exceed 20 pounds. It is important for the pregnant woman to get adequate protein (71 g per day) (IOM, 2002). A low-protein intake during pregnancy is associated with a higher incidence of low-birth-weight infants and should be avoided (IOM, 2002). However, taking too much protein also is unwise. Randomized controlled studies have shown that supplementary protein can decrease birth weight and increase mortality (Rush et al., 1980; Sloan et al., 2002). In addition, the Recommended Dietary Allowance (RDA) for carbohydrates for pregnant women is 175 g per day (IOM, 2002), and is important for prevention of hypoglycemia. Thus, a low-carbohydrate, high-protein diet is not appropriate during pregnancy. AMDRs for protein and carbohydrate intake for pregnant women are 10 to 35 percent and 45 to 65 percent, respectively (IOM, 2002).

Lactation—Moderate weight reduction while breastfeeding is safe and does not compromise weight gain of the infant (ACOG, 2002). The RDA for protein for breastfeeding women is 71 g per day (IOM, 2002). The RDA for carbohydrate increases during lactation to 210 g per day (IOM, 2002). AMDRs for protein and carbohydrate intake for breastfeeding women are 10 to 35 percent and 45 to 65 percent respectively (IOM, 2002).

Supplementary Information—Scientific Support for Weight Loss and Weight

Management Recommendations

The National Heart, Lung, and Blood Institute, in cooperation with the National Institute of Diabetes & Digestive & Kidney Diseases, released the first Federal guidelines on the identification, evaluation, and treatment of overweight and obesity using an evidence-based model and methodology (NIH, NHLBI, 1998). The guidelines present recommendations for the assessment of overweight and obesity and establish principles of safe and effective weight loss.

The guidelines' definition of overweight is based on research that relates BMI to the risk of death and illness. The 24-member expert panel that developed the guidelines identified overweight as a BMI of 25 to 29.9 and obesity as a BMI of 30 and above, which is consistent with the definitions used in many other countries. BMI describes body weight relative to height and is strongly correlated with total body fat content in adults. According to the guidelines, a BMI of 30 is about 30 pounds overweight and is equivalent to 221 pounds in a 6' person and to 186 pounds in someone who is 5'6". The BMI values apply to both men and women. Some very muscular people may have a high BMI without health risks, but they represent a very small percentage of the population.

Also recommended in the guidelines is the determination and tracking of waist circumference, which is strongly associated with abdominal fat. Excess abdominal fat is an independent predictor of disease risk. A waist circumference of over 40 inches in men and over 35 inches in women signifies increased risk in those whose BMI is 25 to 34.9.

According to the guidelines, the most successful strategies for weight loss include calorie reduction, increased physical activity, and behavior therapy designed to improve eating and physical activity habits. Recommendations regarding the goal and rate of weight loss follow:

- The initial goal of treatment should be to reduce body weight by about 10 percent from baseline, an amount that reduces obesity-related risk factors. With success, and if warranted, further weight loss can be attempted.
- A reasonable timeline for a 10 percent reduction in body weight is 6 months of treatment, with a weight loss of 1 to 2 pounds per week.

Question 4: What Is the Relationship Between the Consumption of Energy-Dense Foods and BMI?

Conclusions

Available data are insufficient to determine the contribution of energy-dense foods to unhealthy weight gain and obesity. However, consuming energy-dense meals may contribute to excessive caloric intake. Conversely, eating foods of low energy density may be a helpful strategy to reduce energy intake when trying to maintain or lose weight.

Rationale

This conclusion is supported by the Committee's review of six short-term studies, one longitudinal study, and two longer-term randomly controlled trials, as summarized below.

The energy density of a food (kcal/100 g) depends on its content of fat, carbohydrate, protein, and water. Of particular importance is the content of fat (which provides twice the calories per g compared to carbohydrate and protein) and of water (which provides no calories). The air content of foods contributes to their volume rather than to their energy density.

Short-Term Studies

Short-term studies (ranging in length from a single test meal to 5 days of feeding) consistently demonstrate that the *ad libitum* consumption of foods results in significantly higher total energy intakes when the food offered is high in energy density than when it is low in energy density (Bell et al., 1998; Bell and Rolls, 2001; Duncan et al., 1983; Rolls et al., 1999a; Stubbs et al., 1998). In a study by Duncan et al. (1983), satiety ratings from low energy density (LED) and high energy density (HED) meals were compared in a group of obese and nonobese subjects. Individuals on the LED diet reached satiety at a mean daily energy intake that was one-half that of the mean daily energy intake of the individuals on the HED diet (1,570 versus 3,000 kcal). This higher intake of energy for those consuming HED meals *ad libitum* has been attributed to a delay in the development of satiety with more energy-dense foods (Duncan et al., 1983; Rolls et al., 1999a). In the Duncan study, the energy density of the HED diet was approximately twice that of the LED diet. Thus, in consuming half the mean daily energy intake of the HED, those on the LED consumed roughly the same amount of food (by weight) as those on the HED diet.

In the studies discussed in the above paragraph, the LED and HED diets varied from each other in macronutrient distribution. Results similar to those reported above were obtained in studies in which energy density was manipulated without altering the macronutrient distribution. This was achieved through covert changes in energy density (Rolls et al., 1999a; Stubbs et al., 1998) or by increasing the water content of foods (Rolls et al., 1999b). Therefore, the short-term effects of energy density on satiety, total energy intake, and body weight are not necessarily dependent on the fat or carbohydrate content or the percentage of fat or carbohydrate calories in the meal. In most studies, protein and fiber are held constant.

The lower the energy density of a food, the higher the amount (by weight) of food that needs to be consumed to reach a given caloric intake. To discriminate between the effects of energy density and food volume, Rolls and colleagues (2000a) manipulated food volume by adding variable amounts of air to test meals of identical macronutrient composition and energy content. This study demonstrated that higher-volume meals significantly reduce energy intake, even when the macronutrient distribution is unchanged. In this case, the study focused on volume, and showed that for total energy intake both mass and volume are important.

Randomized Controlled Trials

Two longer-term, randomized controlled trials involving overweight individuals provide useful information regarding the satiety and compensatory effects of diets with different energy densities. Although these studies were not conducted to investigate the effect of energy density on caloric consumption specifically, the energy density in the test foods was manipulated, and so the results are useful in this discussion.

In a 9-month *ad libitum* study, Lovejoy and colleagues (2003) replaced one-third of the fat calories with the fat substitute Olestra®, which provides no calories. This study showed that the lower-density Olestra treatment resulted in a weight loss of 6.27 kg during the study period, compared with 4.0 kg in the control group ($p = 0.06$).

A 10-week *ad libitum* food-intake study by Raben et al. (2002) supplemented a standard diet with sweetened drinks and foods. The foods for the control group were sweetened with sucrose, and the foods for the experimental group were artificially sweetened. The result was a significant difference ($p = < 0.001$) in body weight: the control group gained an average of 1.6 kg, whereas the artificial sweetener group lost an average of 1.0 kg.

Other Studies

One cross-sectional study found that the consumption of energy-dense, nutrient-poor foods was a predictor of being overweight (Nicklas et al., 2003), but intake of the foods with low nutrient density explained less than 5 percent of the variance in overweight status. This relationship between the consumption of energy-dense, nutrient-poor foods and weight was not confirmed by others (Bandini et al., 1999; Kant, 2003).

In summary, short-term studies have linked energy density with total energy intake over a period of 1 meal to 5 days. While not specifically performed to investigate the effects of energy density on satiety, two longer randomized trials showed that, compared with diets of high energy density, diets low in energy density resulted in a weight loss relative to the control group. However, evidence that the consumption of energy-dense foods contributes to a change in BMI is still lacking.

Question 5: What Is the Relationship Between Portion Size and Energy Intake?

Conclusion

The amount of food offered to a person influences how much he or she eats; and, in general, more calories are consumed when a large portion is served rather than a small one. Thus, steps are warranted for consumers to limit the portion size they take or serve to others, especially for foods that are energy-dense.

Rationale

These conclusions are supported by the Committee's review of six short-term feeding studies, one longitudinal study, and three observational studies, as described below.

Short-Term Studies

Studies using a short-term *ad libitum* intake model demonstrate that serving larger portions results in a larger volume of food consumed and a higher energy intake (Diliberti et al., 2004; Fisher et al., 2003; Rolls et al., 2002a, 2004a). In a study of 51 men and women, these results occurred whether the portion served was placed on the individual's plate or was selected by the individual from a serving dish (Rolls et al., 2002a). The response of 5-year-old children to portion size appears to be similar to that of adults: increased energy intake from larger portion sizes (Rolls et al., 2000b). This study showed that children younger than 3 years consumed similar volumes of food when served different portion sizes; but, by age 5, they increased their intake when served larger portions (Rolls et al., 2000a). Another study by the same group showed that large portion sizes have different effects on energy intake in children age 3 to 5 depending on whether the food is served on individual plates or the children serve themselves from a serving dish (Fisher et al., 2003). When children served themselves, they spontaneously

controlled their portion size and consumed similar amounts of energy from large and small serving dishes.

At a given level of caloric intake, selecting lower energy-density foods allows individuals to consume a larger quantity of food and thus reach satiety sooner (Rolls et al., 2000a, 2002a, 2004b).

Other Studies

The Committee's search did not identify any randomized controlled trials evaluating the role of portion size on energy intake or BMI (Hannum et al., 2004). One longitudinal study in children reported a positive relationship ($p < 0.05$) between portion size and body weight (McConahy et al., 2002). Several other observational studies have reported that a secular increase in portion size coincides with the rise in obesity in the United States over the past decades (Nielsen and Popkin, 2003; Smiciklas-Wright et al., 2003; Young and Nestle, 2002, 2003).

Overall, the evidence supports the conclusion that servings that are too large may be part of the "obesogenic" environment, inasmuch as they facilitate excess consumption of energy.

Unresolved Issues

What Is the Relationship Between Breakfast Consumption and BMI?

One randomized clinical trial (RCT) and two longitudinal studies in the literature were reviewed. The purpose of the RCT was to study the effect of eating or not eating breakfast on the outcome of a weight-loss trial (Schlundt et al., 1992). The breakfast group ate three meals a day and the no-breakfast group ate two meals a day. The energy content of the two diets was identical. There was no significant difference in weight loss at 12 weeks.

Two longitudinal studies, one in children (Berkey et al., 2003) and one in adults (Ma et al., 2003), provide relevant data. Berkey et al. (2003) studied more than 14,000 children age 9 to 14 years in 1996, using data from mailed questionnaires. Overweight children who never ate breakfast lost more body fat over the year of follow-up than overweight children who ate breakfast nearly every day; however, normal weight children who never ate breakfast gained weight comparable to that of normal weight children who ate breakfast nearly every day. Thus, this study is inconclusive.

The *Seasonal Variation Blood Cholesterol Study* conducted in 1994–1998 evaluated the relationship between eating patterns and obesity. Odds ratios were adjusted for other obesity risk factors, including age, sex, physical activity, and total energy intake. A greater number of eating episodes per day were associated with a lower risk of obesity (odds ratio for four or more eating episodes versus three or fewer episodes was 0.55, 95 percent confidence interval: 0.33, 0.91). In contrast, skipping breakfast was associated with an increased prevalence of obesity (odds ratio = 4.5, 95 percent confidence interval: 1.57, 12.90) (Ma et al., 2003).

A number of cross-sectional studies have reported positive associations between measures of adiposity in children and skipping breakfast (Gibson and O'Sullivan, 1995; Ortega et al., 1998; Pastore et al., 1996; Summerbell et al., 1996; Wolfe et al., 1994).

Information from the U.S. National Weight Loss Registry indicates that eating breakfast is an important factor in maintaining weight loss over time (Wyatt et al., 2002).

Using data from the 1977–1978 *Nationwide Food Consumption Survey*, Morgan and colleagues reported that skipping breakfast lowered the nutritional quality of the diets of adults (Morgan et al., 1986) and of older adults (Morgan and Zabik, 1984).

Thus, there is suggestive evidence from cross-sectional studies and longitudinal studies that eating breakfast is likely to promote healthy weight and improve the nutritional quality of the diet, but more studies are needed before a definitive conclusion can be reached. However, while the evidence is inconclusive that eating breakfast may help to manage body weight, eating breakfast regularly does not increase the risk of gaining weight. Therefore, adults and children should not skip breakfast because of concerns that breakfast leads to overweight or obesity. Additionally, skipping breakfast may lower the nutritional quality of the diet.

What Is the Evidence To Support Caloric Compensation for Liquids Versus Solid Foods?

People of normal weight typically balance their energy intake throughout the day (or over a few days). If a person eats a large breakfast, he or she will tend to consume fewer calories at lunch, and vice-versa. Meal-to-meal *caloric compensation* (the ability to regulate energy intake with minimal conscious effort, such as reducing the amount of food consumed on some occasions to compensate for increased consumption at other times) is an important mechanism to avoid excess caloric intake and undesired weight gain. While several studies have shown that fluid calories cause less compensation and therefore may result in the overconsumption of calories, others have yielded opposite or inconclusive results.

At least 62 studies have examined the impact of liquid and solid foods on satiety and energy compensation. The numerous factors that influence satiation must be considered when evaluating this body of literature. They include the amount or volume of food; the food's palatability, consistency, viscosity, and texture; the time the food was administered; the time between the pre-load and the next meal; the subjects' psychological and physiological characteristics; the sample size; and the methods used to measure satiety and consumption. Other critical factors include the subjects' metabolic regulatory systems, such as the blood glucose response to food (Almiron-Roig et al., 2003; Anderson and Woodend, 2003; Mattes and Rothacker, 2001).

Some studies on pre-loading have shown that solids were more satiating than liquids, other studies found the opposite, and yet others found no differential effects at all. A review by Almiron-Roig et al. (2003) summarizes the contradictions in 18 studies. An earlier literature review of 40 pre-load studies by Mattes revealed that dietary compensation for changes in energy intake via fluids is less precise than when solid foods are manipulated (Mattes, 1996). On the other hand, a review by Anderson and Woodend (2003), quantifies the reduction of food intake after pre-loads of various sugars. A study that used a within-subject design in the laboratory showed that, compared with a sugar-containing liquid, a sugar-containing solid had an equal impact on food ingestion if the pre-load periods were the same (Almiron-Roig and Drewnowski, in press 2004).

In recent years, concurrent with the obesity epidemic, satiety studies have examined the effects of increased consumption of energy-containing, nutrient-poor beverages on subsequent intake (Almiron-Roig et al., 2003). Soft drinks are often described as primarily thirst-quenching liquids, but juices and milk are said to be liquid foods with a greater satiating power. One recent within-subjects designed study (n = 32) found that 3 energy-containing beverages (regular cola, 1 percent milk, and orange juice) did not differ in their effects on satiation or the temporal profiles of hunger, fullness, or thirst; they were, however, more satiating than sparkling water ($p < 0.01$) (Almiron-Roig and Drewnowski, 2003).

Some of the confusion results from interactions among physical volume, energy density, and portion size. A controlled study of 36 women found that doubling the volume of a liquid food without changing the energy content significantly decreased the liquid's palatability ratings and increased sensory-specific satiety ($p < 0.05$) (Bell et al., 2003). Another study found that increases in portion size and energy density led to independent and additive increases in energy intake ($p < .0001$) (Tanja et al., 2004). A further study with 28 lean men found that increasing the volume of a pre-load beverage by incorporating air, independent of energy density, reduced energy intake ($p < 0.04$) (Rolls et al., 2000a).

A few studies have compared calorie compensation in obese and nonobese subjects. Duncan et al. (1983) indicated that obese and nonobese subjects are comparable in their satiety ratio, energy consumption, eating time, and food acceptance. Rolls and Roe (2002b) found that energy intake by both lean and obese women were affected by the volume of liquid food infused intragastrically. Furthermore, Rolls et al. (1999a) and Bell and Rolls (2001) found that both lean and obese women were influenced by energy density across all fat contents in food. However, further research is necessary to evaluate eating cues and calorie compensation in obese as well as nonobese subjects.

Studies of children suggest that they respond to dietary energy density and that, although their individual meal intakes are erratic, 24-hour energy intakes are relatively well regulated. These studies also report that children's early learning about food is constrained by their genetic predispositions, including the unlearned preference for sweet and salty tastes, and the rejection of sour and bitter tastes. Evidence of individual differences in the regulation of energy intake has been documented in preschool children. These individual differences in self-regulation are associated with differences in child-

feeding practices and with children's adiposity. Initial evidence indicates that imposition of stringent parental controls can potentiate preferences for high-fat, energy-dense foods, limit children's acceptance of a variety of foods, and disrupt children's regulation of energy intake by altering their responsiveness to internal cues of hunger and satiety (Birch and Fisher, 1998).

In summary, the evidence is conflicting that liquid and solid foods differ in their effect on calorie compensation.

Summary

Thirty minutes of at least moderate physical activity on most days provides important short- and long-term health benefits for adults and up to 60 minutes of at least moderate-intensity physical activity might be needed to avoid unhealthy weight gain. Children and adolescents need at least 60 minutes of moderate to vigorous physical activity on most days for maintenance of good health and fitness and for healthy weight during growth. The amount of physical activity that weight-reduced adults need to avoid weight regain is estimated to be from 60 to 90 minutes daily at moderate intensity.

Resistance exercise training increases muscular strength and endurance and maintains or increases lean body weight. Physical activity that involves loading the skeleton is especially beneficial for bone health.

Weight maintenance depends on a balance of energy intake and energy expenditure, regardless of the proportions of carbohydrate, fat, and protein in the diet. To promote recommended nutrient intakes and the adoption of healthy lifestyle changes while losing or maintaining weight, the Committee recommends diets that provide 45 to 65 percent of calories from carbohydrate, 20 to 35 percent of calories from fat, and 10 to 35 percent of calories from protein. Eating foods of low energy density may be a helpful strategy to reduce energy intake when trying to maintain or lose weight. Similarly, limiting the portion size of food eaten or served to others may help control calorie intake.

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Section 3: Discretionary Calories

Discretionary calories can be viewed from two different perspectives—in the context of (1) the sedentary lifestyle and typical food consumption of Americans or (2) diet planning.[1] Both perspectives are covered in this section.

The daily amount of food a person needs to consume is driven by two factors: (1) the need to meet recommended nutrient intakes, and (2) the need to consume enough calories to match energy expenditure and therefore maintain a stable weight. By carefully choosing foods with higher-nutrient densities and/or lower-energy densities, people can meet recommended nutrient intakes while still consuming fewer calories than their daily energy needs. In this situation, an individual has a certain amount of calories left in his or her daily caloric allowance—calories that can be used flexibly, since nutrient needs already have been fulfilled. The Committee named these remaining calories ***discretionary calories***, and defined them as the difference between total energy requirements and the energy consumed to meet recommended nutrient intakes.

Discretionary Calories in the Context of the Sedentary Lifestyle and Typical Food Consumption of Americans

Because of sedentary lifestyles and food choices that frequently are relatively high in added sugars and solid fats, most Americans have used up discretionary calories even before meeting recommendations for nutrient intakes. The maximum amount of discretionary calories is based on the difference between their total daily calorie requirement and the number of calories used to meet nutrient recommendations.

Discretionary calories can be available *only* when the amount of calories used to meet recommended nutrient intakes is less than the total daily calorie expenditure. The magnitude of this difference, and whether it is positive or negative, depends on two factors: (1) the nutrient content of the foods consumed, and (2) the total energy requirement, which, in turn, is greatly dependent on the level of physical activity.

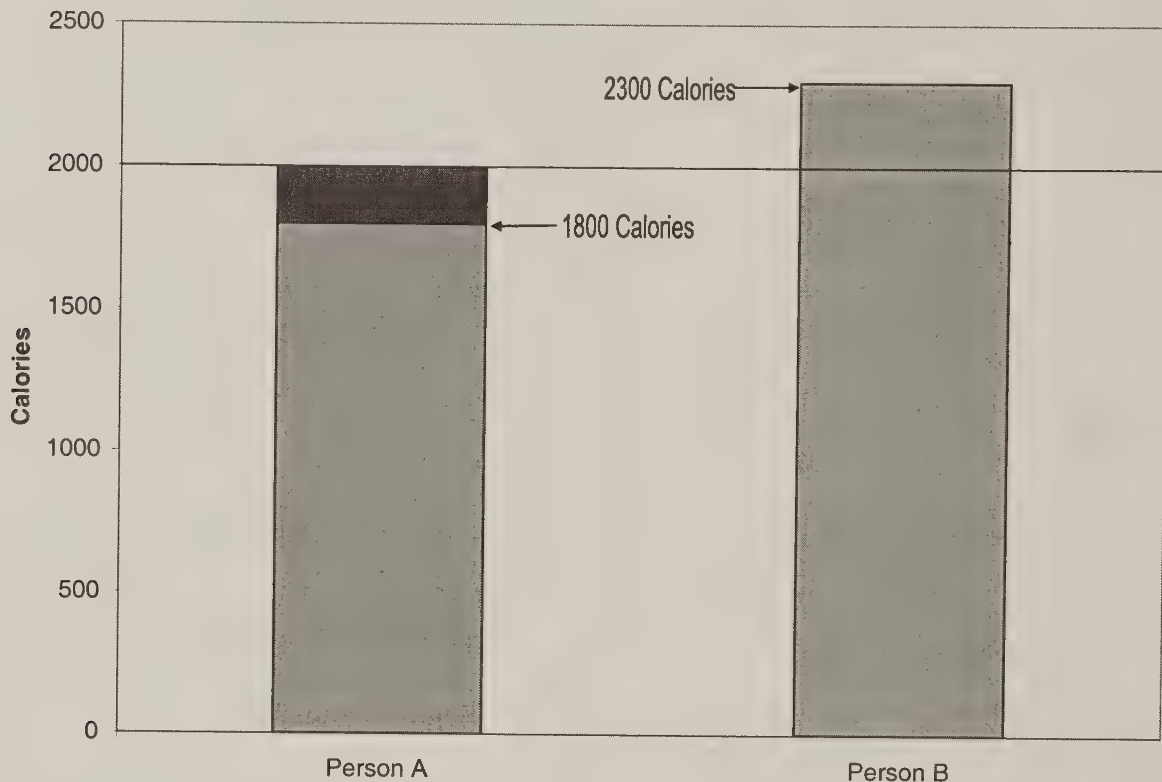
Figure D3-1 presents an illustrative example of the concept of discretionary calories. Individuals A and B have the same estimated energy requirement (EER) of 2,000 kcal per day. However, Person A consumes foods that are rich in essential nutrients and low in added sugars and solid fats, and therefore meets his or her recommended nutrient intake for essential nutrients by consuming only 1,800 kcals in a day. This person has 200 kcals available as *discretionary* calories that day. Person B, on the other hand, by consuming nutrient-poor, energy-dense foods, consumes 2,200 kcals in a day, exceeding his total caloric needs by 200 kcals. Thus, this person not only has no discretionary calories, he or she has an excess caloric intake. If this caloric excess continues, Person B will gain weight gradually. Furthermore, in spite of consuming more calories than Person A, Person B may not be consuming his or her recommended amounts of nutrients because he or she consumes predominantly nutrient-poor, energy-dense foods.

This latter situation of overconsuming calories appears to be the most common in the U.S. population. Food intake surveys (e.g., the *National Health and Nutrition Examination Survey* (NHANES)) show that most adults have used up all or most of their discretionary calories. At present, Americans are consuming calories in excess of calorie needs (as manifested by the high prevalence of overweight and obesity) (Flegal et al., 2002; Hedley et al., 2004; Ogden et al., 2002). Many Americans, however, have inadequate intakes of nutrients. (See Part D, Section 1, "Aiming To Meet Recommended Intakes of Nutrients.") This pattern of nutrient inadequacy in the face of calorie excess results because Americans often consume nutrient-poor foods (e.g., sugar-sweetened beverages), because they choose to consume more energy-dense foods (e.g., whole-fat rather than nonfat milk), and because they are sedentary. Hence, persons who follow typical American eating and activity patterns have used up all their discretionary calories and more likely are consuming diets well in excess of their energy requirements for their age, gender, and physical activity level.

It seems clear that the desirable goal for a person is to have some discretionary calories available. This would allow more flexibility in food choices, and will give extra room to consume additional healthy foods, such

[1] This is the approach used in Section D1 of this report. Tables D1-13 and D1-14 use a precise definition for discretionary calories for use in diet planning.

Figure D3-1. Illustrative Example of the Discretionary Calories Concept



Person A, by consuming nutrient-dense, lower energy dense foods fulfills his essential nutrient needs by consuming only 1,800 calories—less than his total daily energy allowance of 2,000 kcals per day. The remaining 200 calories are *discretionary calories*. Person B consumes low-nutrient, high-fat and added sugars foods, and exceeds his total caloric allowance. Person B has no discretionary calories, and is consuming an excess energy that, over time, will result in undesirable weight gain.

as fruits and vegetables. How can a person increase his or her discretionary calories? There are two ways:

1. By increasing physical activity—Burning more calories increases total caloric needs, and increases the maximum amount of calories a person can consume daily. The active level is the desirable level of physical activity (see below and also Part D, Section 2 "Energy").
2. By consuming nutrient-dense foods that are relatively lower in energy density (i.e., a healthy diet).

Estimating Discretionary Calories for Meal Planning

To estimate how many discretionary calories different groups might have available, the Center for Nutrition and Public Policy (CNPP) provided the Committee with estimates of essential calories obtained using data from the U.S. Department of Agriculture (USDA) food intake pattern and estimates of energy requirements.

Discretionary calories =
Total estimated daily energy requirement (kcal) minus essential calories.

The estimated daily energy requirement is calculated using the method described below, and the value for essential calories is calculated by estimating the total number of calories provided by the specified amounts of foods for that calorie level from Table D1-13 (see also "Essential Calories" below).

Calculating the Estimated Energy Requirement

To estimate how many discretionary calories persons might have available if they followed the revised USDA food pattern, USDA's CNPP used the following equation: (for a calculation to estimate energy requirement for children, see *Dietary Reference Intakes*

for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Institute of Medicine [IOM], 2002)[2]:

Daily estimated energy requirement (kcal) = A + B x age in years + PA x (D x weight in kg + E x height in meters)

***where:* A** = constant term = 662 for men, 354 for women

B = age coefficient = 9.53 for men, 6.91 for women

PA = physical activity coefficient =

	Men	Women	
Sedentary	1.00	1.00	for PAL >1.0<1.4)
Moderately Active	1.11	1.12	for PAL >1.4<1.6)
Active	1.25	1.27	for PAL >1.6<1.9)

D = weight coefficient = 15.91 for men, 9.36 for women

E = height coefficient = 539.6 for men, 726 for women

Sedentary means a lifestyle that includes only the light physical activity associated with typical day-to-day life.

Moderately Active means a lifestyle that includes physical activity equivalent to walking about 1.5 to 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life. This represents activity at the lower limit of the physical activity recommendation for adults (i.e., a minimum of 30 minutes of at least moderate intensity physical activity) (see Part D, Section 2, "Energy").

Active means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life. This corresponds to a minimum of 60 minutes of at least moderate intensity physical activity (see Part D, Section 2, "Energy").

[2] The Institute of Medicine report includes four levels of physical activity in their discussion of estimating energy requirements. The Committee uses three levels in this example, roughly equivalent to the first three levels in the Institute of Medicine report.

Essential Calories

Essential calories represent the number of calories needed to meet recommended nutrient intakes through the consumption of foods (from the basic food groups) in their low-fat or no-added sugars forms (see note on discretionary calories in Table D1-13 (The Revised USDA Food Intake Pattern for Meeting Recommended Nutrient Needs) and Table D1-14 (Discretionary Calories in the Revised USDA Food Intake Pattern). For the purposes of estimating essential calories, all the foods are present in their nutrient-dense, low-energy lean or low-fat forms without any added sugars. That is,

- Only nonfat milk is included from the milk group—cheese and even low-fat milk contain fat that is counted as part of discretionary calories.
- The meats are very lean.
- The grain products do not include sweetened cereals, muffins, or others that contain added sugars and/or added fat.
- The vegetables do not include items made with fat, such as French fries.
- The fruits do not include fruits canned in syrup or other fruits and juices that contain added sugars.
- The oils and *trans*-free soft margarines included in the calculation of essential calories are amounts that meet essential fatty acid needs and also contribute toward vitamin E needs.

Amounts of Discretionary Calories That Can Be Available

By referring to Table D1-13 in Section 1, one can find the estimated number of discretionary calories that can be available when using the Revised USDA Food Intake Pattern for diet planning. This number ranges from 154 calories for young children whose energy requirement is 1,000 calories to 334 for persons whose energy requirement is 3,000 calories. Table D1-14 identifies many of the sources of discretionary calories.

Typical Total Energy Needs of Different Population Groups

Table D3-1 gives estimates of the total energy requirement of people in different age and/or sex groups for three levels of physical activity. These estimates can provide a starting point for people who want an idea of approximately how many calories are needed to maintain their weight.

Table D3-1. Estimated Energy Requirements for Each Age/Gender Group at Three Levels of Physical Activity (These levels are based on Estimated Energy Requirements (EER)[1] from the Institute of Medicine Dietary Reference Intakes Macronutrients Report, 2002. See the notes for additional information.)

Gender	Age	Sedentary	Activity Level[2] Moderately Active	Active
Child	2–3	1,000	1,000–1,400[3]	1,000–1,400
Female	4–8	1,200	1,400–1,600	1,400–1,800
	9–13	1,600	1,600–2,000	1,800–2,200
	14–18	1,800	2,000	2,400
	19–30	2,000	2,000–2,200	2,400
	31–50	1,800	2,000	2,200
	51+	1,600	1,800	2,000–2,200
Male	4–8	1,400	1,400–1,600	1,600–2,000
	9–13	1,800	1,800–2,200	2,00–2,600
	14–18	2,200	2,400–2,800	2,800–3,200
	19–30	2,400	2,600–2,800	3,000
	31–50	2,200	2,400–2,600	2,800–3,000
	51+	2,000	2,200–2,400	2,400–2,800

Notes:

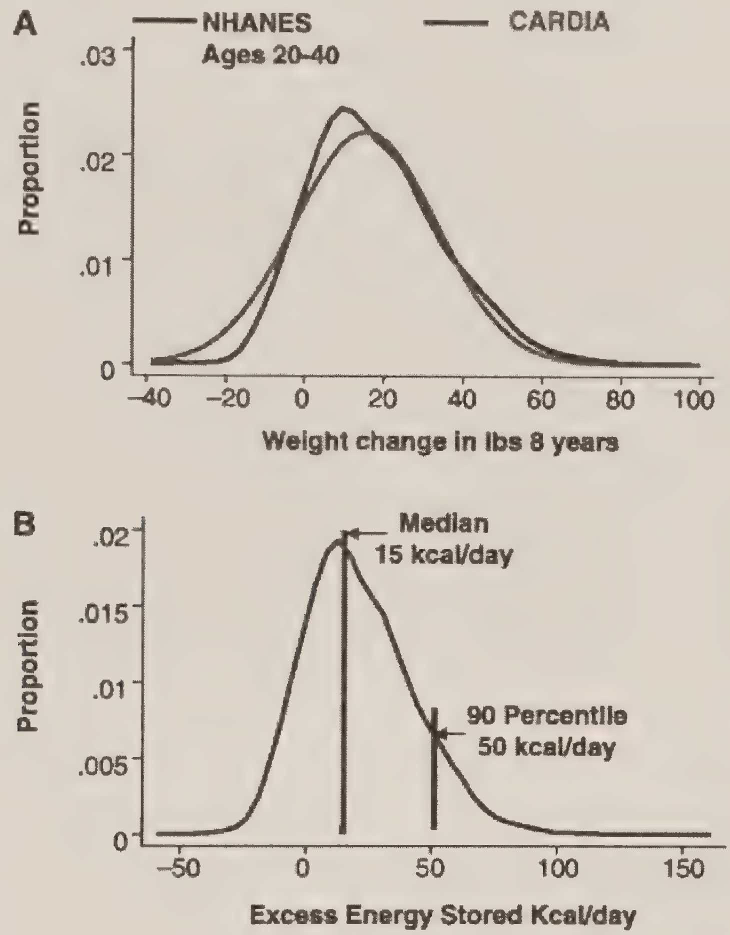
[1]EERs are the Estimated Energy Requirements from the IOM Dietary Reference Intakes macronutrients report, 2002, calculated by gender, age, and activity level for reference-sized individuals. "Reference size," as determined by IOM, is based on median height and weight for ages up to age 18, and median height and a weight for that height to give a BMI of 21.5 for adult females and 22.5 for adult males.

[2]**Sedentary** means a lifestyle that includes only the light physical activity associated with typical day-to-day life. **Moderately Active** means a lifestyle that includes physical activity equivalent to walking about 1.5 to 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life. **Active** means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life.

[3]The calorie ranges shown are to accommodate needs of different ages within the group. For children and adolescents, more calories are needed at higher ages. For adults, fewer calories are needed at higher ages.

In the United States, a large proportion of the adult population is consuming more calories than expended as evidenced by gradual weight gain. The average 8-year weight gain among subjects age 20 to 40 was 14 to 16 pounds in the longitudinal CARDIA study and in the cross-sectional NHANES data set (Hill et al., 2003). Hill and colleagues (2003) estimated the distribution of weight gain within the population and the amount of excess energy storage that would be required to support this population-wide pattern of weight gain (see Figure D3-2). The authors estimated that 90 percent of the population consumed up to 50 kcal per day in excess of their caloric requirement during this 8-year period, and this resulted in the weight gain of about 2 pounds per year. The authors hypothesized that a caloric deficit of as few as 50 to 100 kcal per day could prevent weight gain or promote modest weight reduction in about 90 percent of the population.

Figure D3-2. (A) The Distributions for Weight Change Over an 8-Year Period, Estimated from the NHANES and CARDIA Studies. (B) A Distribution of the Daily Energy Accumulation on the Adult Population Over the 8-Year Period, Assuming a Linear Accumulation of Body Energy (Hill et al., 2003).



Physical Activity and Discretionary Calories

Increasing physical activity is the way to increase one's total energy requirement for weight maintenance. Thus, increasing physical activity is the major way a person can increase the amount of discretionary calories available. Another way is to choose nutrient-dense foods that are in their most lean, low-calorie form to meet one's nutrient needs.

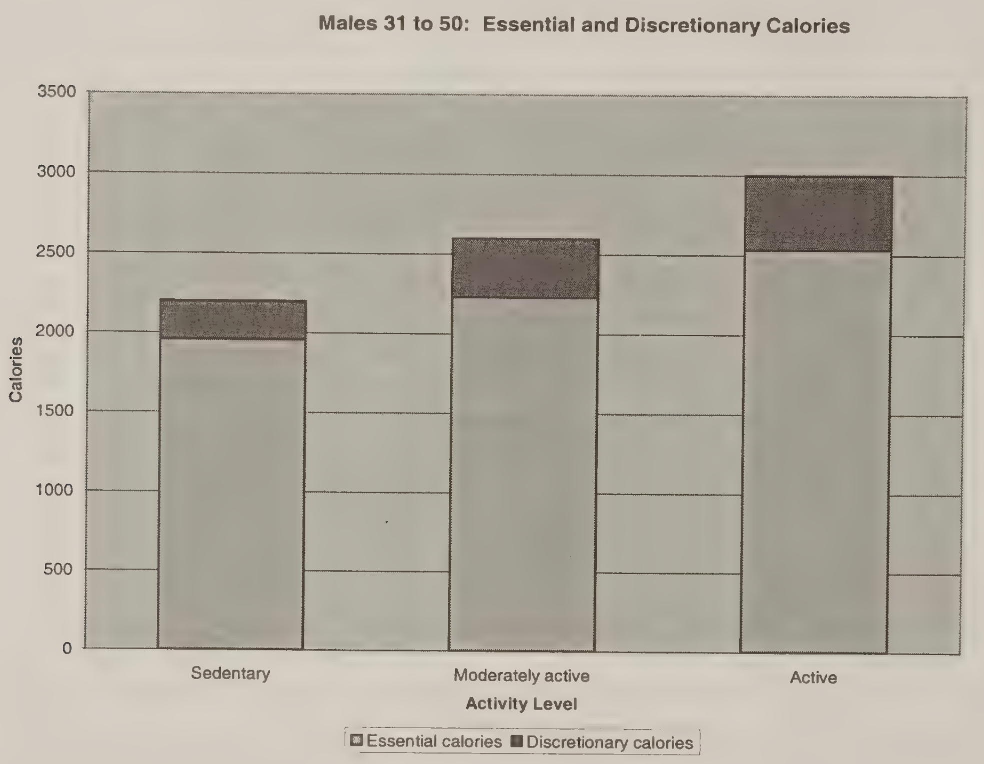
Figures D3-3a and D3-3b graphically represent estimates of the number of discretionary calories that would be available for men and women at three different activity levels—sedentary, moderately active, and active,[3] assuming that they consume nutrient-dense foods that are relatively low in energy density. That is, the levels of physical activity addressed in these figures range from only the light physical activity associated with typical day-to-day life (i.e., sedentary) to about 60 minutes of moderate physical activity daily in addition to the light physical activity of daily living (i.e., active). Some individuals may need up to 60 minutes of at least moderate intensity physical activity to prevent unhealthy weight gain. The amount of physical activity that weight-reduced adults need to avoid weight regain is estimated to be from 60 to 90 minutes daily at moderate intensity.

These figures show that the more physically active a person is, the more calories he or she requires to attain energy balance, and the more flexibility there is in consuming those calories after meeting recommended nutrient intakes. These estimates were made for individuals of median height and healthy body weight. Estimates would be higher for larger persons.

Note in Figures D3-3a and D3-3b that essential calories increase slightly with increased physical activity. This is because the recommended nutrient intake for fiber increases as an individual engages in more physical

[3] As indicated in the equations above, these are the three physical activity levels used for the estimation of energy needs. These levels differ from intensity levels used by exercise physiologists (i.e., low, moderate, and vigorous).

Figure D3-3a. Estimate of Discretionary Calories Available Based on the Level of Physical Activity for Males Age 31 to 50. (Estimated energy requirements from the IOM Dietary Reference Intakes Macronutrients Report, 2002, are calculated by median height (1.77 m) and weight (70 kg) for that height to give a BMI of 22.5 for a typical adult male, age 30.)

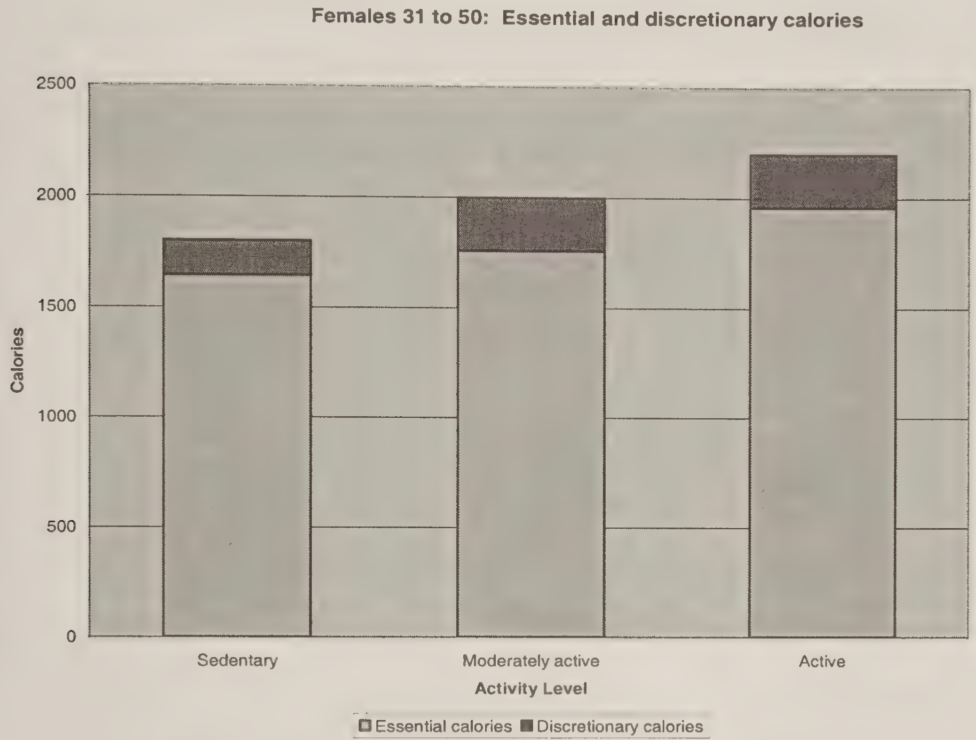


Sedentary represents in dark gray the essential calories used to consume a relatively nutrient-dense food pattern to meet nutrient needs for a sedentary male and on top of the essential calories, in light gray, the remaining, or discretionary, calories to achieve energy balance based on the USDA food modeling system. Sedentary means a lifestyle that includes only the light physical activity associated with typical day-to-day life.

Moderately Active represents in dark gray the essential calories used to consume a relatively nutrient-dense food pattern to meet nutrient needs for a moderately active male and on top of the essential calories, in light gray, the remaining, or discretionary, calories to achieve energy balance based on the USDA food modeling system. Moderately active means a lifestyle that includes physical activity equivalent to walking about 1.5 to 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life and results in a slight increase in essential calories for the moderately active man.

Active represents in dark gray the essential calories used to consume a relatively nutrient dense food pattern to meet nutrient needs for an active male and on top of the essential calories, in light gray, the remaining, or discretionary, calories to achieve energy balance based on the USDA food modeling system. Active means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life, and results in a slight increase in essential calories for the active man.

Figure D3-3b. Estimate of Discretionary Calories Available Based on the Level of Physical Activity for Females age 31 to 50. (Estimated energy requirements from the IOM Dietary Reference Intakes Macronutrients Report, 2002, are calculated by median height (1.63 m) and weight (57 kg) for that height to give a BMI of 21.5 for a typical adult female, age 30.)



activity. It also allows for the food intake pattern to come closer to meeting recommended intakes of potassium and vitamin E.[4] This means that the increase in discretionary calories earned through physical activity may be slightly smaller than expected. If foods rich in fiber, potassium, and vitamin E are consumed while meeting other nutrient needs, more of the calories earned through physical activity could be considered discretionary calories.

The essential calorie values shown in Figures D3-3a and D3-3b are estimates obtained using a specific food modeling approach that incorporates commonly used foods that are not necessarily the richest sources of nutrients. This means that one could increase the number of discretionary calories available by making food selections (from the basic food groups) that are especially rich in the nutrients that tend to be in short supply—especially vitamin E, potassium, and fiber. By meeting recommended nutrient intakes with a smaller number of calories, more discretionary calories become available. However, since the calculations of essential calories assume a healthier diet than most Americans currently consume, selecting foods that are even richer in nutrient content than the foods used in the food modeling approach could be a challenge.

Ways that Discretionary Calories are Used Up

Most people have no discretionary calories because of their sedentary lifestyle and selection of energy-dense foods. However, if discretionary calories are available, they can be used in a variety of ways. Often, discretionary calories come from intrinsic fats found in foods in one or more of the basic food groups. For example, drinking low-fat milk rather than skim milk uses some discretionary calories, as does eating a medium-fat hamburger patty instead of a lean cut of meat. The USDA food modeling method counts most solid fats and all added sugars as "discretionary." Alcoholic beverages also count as discretionary calories. Discretionary calories add up quickly. For example, a 12-ounce soft drink counts as about 150 discretionary calories because of the added sugars it provides, the fat in one cup of 2 percent milk counts as about 32 discretionary calories, and a 12-ounce can of

[4] Table D1-12, "Nutrients in the Revised USDA Food Intake Pattern" shows that the lowest calorie pattern is especially low in vitamin E, and that the lower calorie pattern does not provide 100 percent of the recommended intake of potassium.

beer counts as about 150 discretionary calories. This exceeds the total amount of discretionary calories that could be available for many persons.

Key Points Regarding Discretionary Calories

- The best way to increase the number of discretionary calories is to increase physical activity (see Figures D3-3a and D3-3b). The greater the amount of physical activity, the more discretionary calories will be available.
- Another way to increase the number of discretionary calories is to make nutrient-dense selections from the basic food groups, especially of foods that are very good sources of vitamin E, potassium, calcium, and fiber.
- For good health, the goal is to be sure to obtain recommended nutrient intakes from the basic food groups and oils/*trans*-free soft margarines before consuming discretionary calories.
- Even if many discretionary calories are available, keeping saturated and *trans* fat intake very low is advisable to help reduce the risk of heart disease (see Part D, Section 4, "Fats").
- Intake of no more than one serving of alcohol per day for women and two servings per day for men is advisable—even if many discretionary calories are available (see Part D, Section 8, "Ethanol").
- For weight maintenance, the aim is to consume essential calories plus discretionary calories to equal total energy expenditure. For weight loss, the aim is to consume essential calories but to consume only part of the discretionary calories. In this way, calorie intake will be less than total energy expenditure, but recommended nutrient intakes will be achieved.

Summary

Discretionary calories are calories remaining when an individual meets his or her recommended nutrient intake while consuming fewer calories than his or her daily energy requirement. Discretionary calories can be available only when individuals consume nutrient-dense, lower-energy density foods and maintain an adequate level of physical activity.

At present, Americans are consuming calories in excess of calorie needs (as manifest by the high prevalence of overweight and obesity) but are not meeting recommended nutrient intakes. This pattern of calorie intakes exceeding energy expenditure results because Americans often consume nutrient-poor and energy-dense foods and because they are increasingly sedentary. Therefore, Americans have few, if any discretionary calories.

To make discretionary calories available or to increase the amount of discretionary calories, individuals need to

- increase their physical activity AND/OR
- consume nutrient-rich foods that are relatively low in energy density in a manner consistent with the dietary patterns recommended in this report.

When available, discretionary calories can be used to consume additional foods from the basic food groups and/or foods in the recommended food groups that are higher in solid fat and/or that contain added sugar.

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Section 4: Fats

Introduction

Fats supply energy and essential fatty acids, and serve as a carrier for the absorption of the fat-soluble vitamins A, D, E, and K, and carotenoids. Fats are a source of antioxidants and numerous bioactive compounds and serve as building blocks of membranes and play a key regulatory role in numerous biological functions. Dietary fat is found in foods derived from both plants and animals.

Fats are composed of triglycerides that consist of fatty acids and glycerol. Individual fatty acids have different biological effects ranging from modulating clinical markers of disease risk to regulating many intracellular biological mechanisms due to changes in intracellular signaling and gene expression (Clarke SD, 2004). Fatty acids modulate lipid metabolism and other physiological systems that affect risk factors for chronic diseases. Whether these effects on health outcomes are beneficial or harmful depend on the specific fatty acids and the mix of fatty acids in the diet and the body. Individual fatty acids are present in foods as mixtures. Different foods are rich sources of specific fatty acids.

Fatty acids are classified on the basis of chain length, degree of saturation (as defined by the number of double bonds in the molecule), and position of the first double bond from the methyl terminus. The fatty acid classes are

- ***Saturated fatty acids***—Saturated fatty acids have no double bonds. They primarily come from animal products such as meat and dairy products. In general, animal fats are solid at room temperature. *Stearic acid* is a saturated fatty acid that has different biological effects than other saturated fatty acids. Important food sources of stearic acid are beef, hydrogenated/partially hydrogenated vegetable oils, and chocolate.
- ***Monounsaturated fatty acids***—Monounsaturated fatty acids (MUFAs) have one double bond. Plant sources that are rich in MUFAs include vegetable oils (e.g., canola oil, olive oil, high oleic safflower and sunflower oils) that are liquid at room temperature and nuts.
- ***Polyunsaturated fatty acids***—Polyunsaturated fatty acids (PUFAs) have two or more double bonds, and may be of two types, based on the position of the first double bond:
  - ***n-6 PUFAs. Linoleic acid***, one of the n-6 fatty acids, is required but cannot be synthesized by humans and, therefore, is considered essential in the diet. A lack of dietary n-6 PUFAs is characterized by rough, scaly skin and dermatitis. Primary sources are liquid vegetable oils including soybean oil, corn oil, and safflower oil.
  - ***n-3 PUFAs. α-linolenic acid*** is an n-3 fatty acid that is required because it is not synthesized by humans and, therefore, is considered essential in the diet. A lack of α-linolenic acid in the diet can result in symptoms of a deficiency including scaly and hemorrhagic dermatitis, hemorrhagic folliculitis of the scalp, impaired wound healing, and growth retardation. It is obtained from plant sources including soybean oil, canola oil, walnuts, and flaxseed. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are n-3 fatty acids that are contained in all fish and shellfish. Fish that naturally contain more oil (e.g., salmon, tuna, trout) (which are called "fish high in n-3-fatty acids" in this report) are higher in EPA and DHA than are lean fish (e.g., cod, haddock, flounder).
- **Trans** ***fatty acids***—*Trans* fatty acids are unsaturated fatty acids that contain at least one double bond in the *trans* configuration. The partial hydrogenation of polyunsaturated oils causes isomerization of some of the remaining double bonds and migration of others, resulting in an increase in the *trans* fatty acid content and the hardening of the oil. Elaidic acid (t9-C18:1) is the predominant *trans* fatty acid found in processed fats. Sources of *trans* fatty acids include hydrogenated/partially hydrogenated vegetable oils that are used to make shortening and commercially prepared baked goods, snack foods, fried foods, and margarine. With respect to *trans* fatty acids, the descriptors "hydrogenated" and "partially hydrogenated" are used interchangeably but convey the presence of elaidic acid in the vegetable oil that has been subjected to the hydrogenation process. For the sake of accuracy, in oil that is fully hydrogenated (i.e., the unsaturated fatty acids have been converted to stearic acid), there are no *trans*

unsaturated fatty acids. Thus, fats that are hydrogenated/partially hydrogenated have variable amounts of *trans* fatty acids depending on the extent of hydrogenation. *Trans* fatty acids also are present in foods that come from ruminant animals (e.g., cattle and sheep). Such foods include dairy products, beef, and lamb. The predominant naturally occurring *trans* fatty acid is *trans*-vaccenic acid (t11-C18:1). Conjugated linoleic acid (c9, t11-C18:2) is derived from vaccenic acid and is found to a lesser extent in foods from ruminant animals.

- ***Cholesterol*** is a sterol present in all animal tissues. Free cholesterol is a component of cell membranes and serves as a precursor for steroid hormones including estrogen, testosterone, aldosterone, and bile acids. Humans are able to synthesize sufficient cholesterol to meet biologic requirements, and there is no evidence for a dietary requirement for cholesterol.

The Dietary Guidelines Advisory Committee (the Committee) placed a strong focus on fats because of the substantial body of research linking different types of fats to blood lipid values and heart health. Lipids and lipoproteins in the blood historically have attracted much interest because of their functions in biological events that underlie the prevention and progression of cardiovascular disease (see Part B, "Introduction," for further information).

Blood Lipids

There are different types of lipids circulating in the blood; cholesterol and triglycerides have been most intensively studied because of the diverse mechanisms by which they modulate risk of cardiovascular disease. Cholesterol and triglycerides are packaged into lipoprotein particles for transport in the circulation. The composition and biological properties of the different lipoprotein fractions varies markedly. The predominant lipoprotein particles are chylomicrons, very-low density lipoproteins (VLDL), low-density lipoproteins (LDL), and high-density lipoproteins (HDL).

- Cholesterol is transported in the blood primarily by LDL, HDL, and VLDL. Chylomicrons transport dietary cholesterol absorbed from the intestine. Total serum cholesterol is the sum amount of cholesterol found in lipoproteins in the blood. A high total cholesterol concentration is a risk factor for coronary heart disease (CHD).
- Triglycerides are a naturally occurring ester of three fatty acids and glycerol. They are the chief constituent of fats and oils and commonly circulate in the blood in the form of lipoproteins, principally in chylomicrons and VLDL. There is a positive relationship between serum triglyceride value and the incidence of CHD. A high triglyceride level is one of the diagnostic criteria for metabolic syndrome, a condition that increases risk of cardiovascular disease. The high, and growing, prevalence of metabolic syndrome (1 in 4 individuals in the United States) has important public health implications (Ford et al., 2002).

Blood Lipoproteins

- Chylomicrons and VLDL are triglyceride-rich lipoproteins that transport dietary and endogenous lipids through the circulation.
- LDL transports about 60 to 70 percent of total serum cholesterol. An increase in LDL cholesterol increases the risk of CHD. Lowering levels of LDL cholesterol reduces the risk for CHD.
- HDL carries approximately 20 to 30 percent of total serum cholesterol. A high level of HDL cholesterol is associated with a reduced risk for CHD and may help prevent atherosclerosis.

Overview of Questions Addressed

This section addresses seven major questions related to different types of fat and how they are related to health.

1. What are the relationships between total fat intake and health?
2. What are the relationships between saturated fat intake and health?
3. What are the relationships between *trans* fat intake and health?
4. What are the relationships between cholesterol intake and cardiovascular disease?
5. What are the relationships between n-6 PUFA intake and health?
6. What are the relationships between n-3 fatty acid intake and health?
7. What are the relationships between MUFA intake and health?

The general search strategies used to find the scientific evidence related to each of these questions appears in Part C. Tables summarizing the findings were prepared for Questions 1 (see Appendix G-3) and 5 (see Table D4-2). USDA's Center for Nutrition Policy and Promotion conducted special analyses related to

nutritional effects of varying the percentages of total fat and of including more fish in food intake patterns. Those analyses are described briefly under Questions 1 and 6, respectively, and in full in Appendix G-2. The Committee relied on findings in the science-based report *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids* (IOM, 2002) and considered findings in the *Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults* (Adult Treatment Panel III [ATP III]) (National Cholesterol Education Program [NCEP], 2002) and the Department of Health and Human Services' Agency for Health Care Research and Quality (AHRQ) report *Effects of Omega-3 Fatty Acids on Cardiovascular Disease* (Wang et al., 2004).[1]

Question 1: What Are the Relationships Between Total Fat Intake and Health?

Conclusion

At low intakes of fat (< 20 percent of energy) and high intakes of carbohydrates (> 65 percent of energy), risk increases for inadequate intakes of vitamin E, α-linolenic acid, and linoleic acid, and for adverse changes in HDL cholesterol and triglycerides. At high intakes of fat (> 35 percent of energy), the risk increases for obesity and CHD. This is because fat intakes that exceed 35 percent of energy are associated with both increased calorie and saturated fat intakes.

[1] The Agency for Healthcare Research and Quality (AHRQ) was developed to provide evidence-based reports and technology assessments that could be used by Federal and State agencies and private or public healthcare organizations. In 1997, AHRQ, then known as the Agency for Health Care Policy and Research (AHCPR), launched its initiative to promote evidence-based practice in every-day care. AHRQ established 12 Evidence-based Practice Centers (EPCs) by awarding contracts to institutions throughout the United States and Canada. The EPCs review relevant scientific literature on clinical, behavioral, and organizational topics that are then used to develop evidence reports and technical assessments. The EPCs are required to provide detailed documentation of methods, rationale, and assumptions used throughout the process. EPCs also collaborate with other medical and research organizations in order to include a broad range of experts in the developmental process. In March 2004, AHRQ released several evidence-based reviews related to n-3 fatty acids, including an evidence-based review on the effects of n-3 fatty acids on cardiovascular disease.

Total fat intake of 20 to 35 percent of calories is recommended for adults and 25 to 35 percent for children age 4 to 18 years. A fat intake of 30 to 35 percent of calories is recommended for children age 2 to 3 years.

Rationale

Overview

The conclusion regarding the recommended range of total fat intake is based on the Institute of Medicine's (IOM's) Acceptable Macronutrient Distribution Range (AMDR) of 20 percent to 35 percent of calories from fat (IOM, 2002). As stated in Section 1, the Committee recommends that the food guidance provided aim to achieve the most recent Recommended Dietary Allowances (RDAs), Adequate Intakes (AIs), and AMDRs for all nutrients. Evidence concerning the health effects of low- and high-fat intakes was obtained from the same IOM report and from more recent publications identified by the Committee's literature search.

The lower limit for fat intake is set at 20 percent of calories because serum triacylglycerol concentrations increase and serum HDL cholesterol concentrations decrease when fat intake is low and carbohydrate intake is high. This, in turn, may increase the risk of CHD. Furthermore, it is difficult to achieve recommended intakes of several nutrients when fat intake is below 20 percent of calories.

The upper limit on total fat intake is related to the saturated-fat content of diets that provide more than 35 percent of calories from fat. Practical efforts to create heart-healthy menus that provide more than 35 percent of energy from total fat result in an unacceptably high content of saturated fatty acids. Because saturated fatty acids are present in all fats, higher intakes of total fat are associated with increased saturated fatty acid intakes. As discussed under Question 2, increasing the saturated fatty acid content of the diet increases the LDL cholesterol concentration, which, in turn, increases the risk of CHD (IOM, 2002). Other reasons for limiting total fat intake have been proposed: (1) diets with more than 35 percent of energy from fat may increase the risk of caloric excess and certain cancers such as breast and colorectal cancer; and (2) high-fat intakes may promote a prothrombotic state, which may increase CHD risk. An association between dietary fat intake and the risk for diabetes has been reported in some epidemiologic studies, but this association may be confounded by various factors, such as obesity (IOM, 2002).

Published Evidence

The IOM report *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids* (IOM, 2002) includes a systematic, extensive review of the scientific literature regarding total fat and carbohydrate intake in relation to weight change, blood lipid concentrations, and metabolic parameters for glucose and insulin. Documentation relevant to the conclusions above is found in the following tables:

- 11-1: Decreased Fat Intake and Body Weight Change in Non- or Moderately-Obese Subjects
- 11-2: Fat and Carbohydrate Intake and Blood Lipid Concentrations in Healthy Individuals
- 11-8: Interventional Studies on the Effect of Dietary Fat on the Metabolic Parameters for Glucose and Insulin in Healthy Subjects

Evidence in Table 11-1 (IOM, 2002), which includes nine short-term and nine long-term intervention studies, reports small losses in body weight with substantial reductions (greater than 4 percentage points) in the percentage of energy consumed as fat. The IOM report concludes that evidence suggests that low-fat diets (diets with a low percentage of calories from fat) tend to be slightly hypocaloric compared to higher fat diets in outpatient intervention trials. Data in Table 11-2 (IOM, 2002), which covers 14 intervention studies, demonstrate that decreasing fat and increasing carbohydrate intake is associated with an increase in serum triacylglycerol concentration and a decrease in plasma HDL cholesterol. Moreover, the reduction in HDL cholesterol that is associated with a low fat intake results in a higher total:HDL cholesterol ratio, which may increase the risk of CHD. Table 11-8 (IOM, 2002), which covers 13 intervention studies, reports a lack of definitive evidence that higher fat intakes impair insulin sensitivity in humans. Collectively, the evidence in these tables provides the rationale for the lower and upper range for fat in the diet.

The conclusions were substantiated further by more recent publications that reported on relationships between fat intake and the metabolic syndrome: five clinical trials (Berrino et al., 2001; Larsson et al., 1999; Lovejoy et al., 2001; Poppitt et al., 2002; Vessby et al., 2001), two reports from conferences sponsored by the National Heart, Lung, and Blood Institute/American Heart Association (Grundy, et al., 2004a), and the American Heart Association/National Heart, Lung, and Blood Institute/American Diabetes Association (Grundy et al., 2004b), and one review paper (Grundy et al., 2002). The evidence is convincing that better weight control improves metabolic syndrome and that modest reductions in total fat intake may facilitate both decreasing one's caloric intake and controlling calories for weight control. For individuals with metabolic syndrome, an isocaloric diet higher in total fat (30 to 35 percent of calories) with an emphasis on unsaturated fatty acids has been shown to improve the clinical profile related to the atherogenic dyslipidemia and insulin resistance.

Special Analyses

At the Committee's request, U.S. Department of Agriculture's (USDA's) Center for Nutrition Policy and Promotion used a modeling process described in Appendix G-2 to examine how changing the percentage of calories from fat may affect the intake of other nutrients. Of particular concern were intakes of the essential fatty acids (linoleic acid and α-linolenic acid), protein, carbohydrates, added sugars, cholesterol, and vitamin E. The analysis produced food patterns that showed the following:

- At 20 percent of calories from fat, few food patterns met the AIs for both linoleic acid and α-linolenic acid. At 25 percent of calories from fat, most did; and at 30 percent and 35 percent, all did. In most cases, protein, fat, and carbohydrate percentages were within the AMDR.
- At calorie levels of 2,600 or more, when only 20 percent of the calories were supplied by fat, 66 to 68 percent of calories were supplied by carbohydrates. To lower the carbohydrate provided by fruits, vegetables, and grains to be consistent with the AMDR of 45 to 65 percent of calories from carbohydrate, the proportion of calories from dietary protein could be increased.
- At 35 percent of calories from fat, the menu modeling resulted in cholesterol levels that were above the standard of 300 mg for energy intakes of 2,800 kcal or higher. This could pose a problem since increases in dietary cholesterol increase LDL cholesterol, which, in turn, increases CHD risk. In a diet that provides more than 30 percent of calories from fat, particular attention must be paid to keeping dietary cholesterol intake at or below the recommended limit (see Cholesterol).
- The amount of vitamin E provided by the patterns consistently increased with increases in the percentage of calories from fat, as well as with increases in the energy content of the pattern. Vitamin E RDAs were met only at the 3,000- and 3,200-calorie levels.

A diet that provides 20 percent of calories from fat could be designed to meet recommended intakes for vitamin E, linoleic, and α-linolenic acid by choosing the foods that are better sources of these nutrients, e.g., certain liquid vegetable oils. Exceptions might occur at the lower calorie levels (i.e., < 1,600 calories).

Positions Taken by Other Expert Groups

Using an evidence-based approach, the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (2002) published the following evidence statement and recommendation related to total fat:

> ***Evidence Statement***
> The percentage of total fat in the diet, independent of caloric intake, has not been documented to be related to body weight or risk for cancer in the general population. Short-term studies suggest that very high fat intakes (>35 percent calories from fat) modify metabolism in ways that could promote obesity. On the other hand, very high carbohydrate intakes (> 60 percent calories) aggravate some of the lipid and non-lipid risk factors common in metabolic syndrome.
>
> ***Recommendations***
> Dietary fat recommendations should emphasize a reduction in saturated fatty acids. Furthermore, in individuals with lipid disorders or metabolic syndrome, extremes of total fat intake—either high or low—should be avoided. In such persons, total fat intakes should range from 25 to 35 percent of calories. For some persons with the metabolic syndrome, a total fat intake of 30 to 35 percent may reduce lipid and nonlipid risk factors.
> (National Cholesterol Education Program Expert Panel, 2002, p. V-12)

The evidence of a relationship between total fat intake and certain cancers is suggestive but not conclusive. The Department of Health and Human Services, National Cancer Institute's PDQ® (Physician Data Query), published the following evidence statements:

- *Colorectal cancer*—Epidemiologic, experimental (animal), and clinical investigations suggest that diets high in *total fat* [italics added], protein, calories, alcohol, and meat (both red and white) and low in calcium and folate, are associated with an increased incidence of colorectal cancer.
- *Prostate cancer*—In general, fat of animal origin seems to be associated with the highest risk. In a series of 384 patients with prostate cancer, the risk of cancer progression to an advanced stage was greater in men with a high fat intake. The announcement in 1996 that cancer mortality rates had fallen in the United States prompted the suggestion that this may be due to decreases in dietary fat over the same time period.
  (*www.cancer.gov/cancerinfo/pdq/prevention*)

A more recent analysis of nutrition and cancer (Bingham and Riboli, 2004) details the difficulty in assessing whether fat intake is a risk factor for breast cancer. In particular, self-reported dietary assessment instruments may not provide an accurate assessment of dietary fat because of measurement error biases (Prentice and Sheppard, 1990). Based on a summary of the literature, total fat seems not to be associated with breast cancer risk (Kushi and Giovannucci, 2002). This conclusion is consistent with the findings of the *Nurses' Health Study* (Holmes et al., 1999), which reported no association between total fat intake and breast cancer.

An evidence-based technical report of the American Diabetes Association included the following statement for dietary fat and diabetes, "Reduced-fat diets when maintained long-term contribute to modest loss of weight and improvement in dyslipidemia" (Franz et al., 2004).

Comparison of the Committee's Findings With Other Recommendations

Both the Adult Treatment Panel (ATP) III (NCEP, 2002) and this Committee agree on the upper limit for total fat recommendations. The basis for the difference in the lower limit for the total fat recommendations—25 percent of calories made by ATP III and 20 percent of calories made by this Committee—is that ATP III focuses on recommendations for individuals at risk for CHD, such as those seeking health care who present with an atherogenic dyslipidemia that is aggravated by a very-low-fat diet. This Committee, by contrast, targets the general public. As stated in Section 1, the Committee is adopting Dietary Reference Intake recommendations from the Institute of Medicine. Thus, consistent with the IOM report (IOM, 2002), which has as a focus on healthy individuals, the 20 percent lower level of total fat in the diet is acceptable.

Total Fat and Children's Health

Total fat intake of 30 to 35 percent of calories is recommended for children age 2 to 3 years. A fat intake of 25 to 35 percent of calories is recommended for children age 4 to 18 years. This is consistent with the AMDR for fat established by the IOM (IOM, 2002). The AMDRs for fat that have been estimated for children are primarily based on a transition from high-fat intakes that occur during infancy to the lower fat recommendations for adults.

Evidence is less clear about whether or not low- or high-fat intakes during childhood can lead to increased risk of chronic diseases later in life. Children can consume fat intakes within the recommended range without compromising intakes of energy and of essential vitamins and minerals (Nicklas and Johnson, 2004). Two large intervention trials successfully reduced children's total fat intake while maintaining vitamin and mineral intakes (Nicklas et al., 1996; Obarzanek et al., 1997). In the *Dietary Intervention Study in Children*, the treatment group consumed 28 percent of calories from total fat; the children experienced normal growth and development and maintained normal nutritional biochemical values (Obarzanek et al., 1997).

Intake Levels

Data from the *Third National Health and Nutrition Examination Survey* (NHANES III) and from NHANES 1999–2000, indicate

- For all ages of the U.S. population, the daily mean percentage of calories from total fat was 32.7 percent (Briefel and Johnson, 2004).
- For children age 2 to 19 years, mean fat intake was 33.5 percent of energy (Troiano et al., 2000).
- Among males age 12 to 19 years, fat accounted for 35.7 percent of calories for non-Hispanic blacks, compared with 33.2 percent for non-Hispanic whites and 34.1 percent for Mexican Americans (Troiano et al., 2000).
- For females age 12 to 19 years, fat intake was 36.1 percent of calories for non-Hispanic blacks compared with 33.4 percent for non-Hispanic whites and 34.1 percent for Mexican Americans (Troiano et al., 2000).

Investigators using data from the *Continuing Survey of Food Intake by Individuals* (CSFII) (1994–1996, 1998) reported the following additional information:

- Fewer than 5 percent of children and adults have intakes below 20 percent of calories from fat. However, approximately 25 percent of children and adults have intakes greater than 35 percent of calories from fat (IOM, 2002).
- Among children age 6 to18 years, intake of total fat was 32 percent of calories (Gleason and Suitor, 2001).

Among adults age 20 to 74, Briefel and Johnson (2004) report that total fat intake decreased from a mean of 36 percent of calories in 1971–1974 to 33 percent of calories in 1999–2000 and ranged from approximately 32 to 36 percent of calories among the different population groups surveyed. However, the absolute level of fat intake has increased: it was 73.4 g in 1989–1991 and 76.4 g in 1994–1996 (Chanmugam et al., 2003). The concurrent increase in total fat intake means that the decrease in the percentage of calories from fat results from an increase in total energy intake coming mainly from carbohydrates.

Question 2: What Are the Relationships Between Saturated Fat Intake and Health?

Conclusion

The relationship between saturated fat intake and LDL cholesterol is direct and progressive, increasing the risk of cardiovascular disease (CVD). Thus, saturated fat consumption by adults should be as low as possible while consuming a diet that provides 20 to 35 percent calories from fat and meets recommendations for α-linolenic acid and linoleic acid. In particular,

- For adults with LDL cholesterol below 130 mg/dL, less than 10 percent of calories from saturated fatty acids is recommended.
- For adults with an elevated LDL cholesterol (≥ 130 mg/dL), less than 7 percent of calories from saturated fatty acids is recommended.[2]

Rationale

This conclusion concurs with the recommendation for saturated fat intake made by the IOM, which is to decrease saturated fat intake as much as possible within the context of a nutritionally adequate diet (IOM, 2002). The IOM recommendation is supported

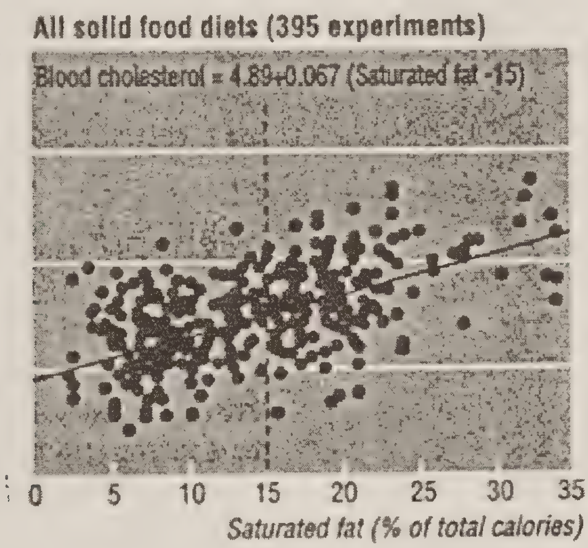
[2] For persons with known heart disease, medical advice and the use of ATP III Panel Guidelines are indicated.

by evidence from a systematic, extensive review of 27 controlled trials. The recommendation that saturated fat be reduced to 10 percent of calories dates back to 1977 with the publication of Dietary Goals for the United States (U.S. Senate, 1977). Since then, the scientific evidence has supported the recommendation that saturated fat intake be further decreased in persons with elevated LDL cholesterol (Dixon and Ernst, 2001). The specific recommendation for less than 7 percent of calories from saturated fat is consistent with the evidence-based recommendation for individuals with an LDL cholesterol ≥130 mg/dl made by the NCEP Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP, 2002); and the Committee's review of 33 more recent controlled trials on saturated fat intake and health and of a meta-analysis.

Saturated Fat and Blood Lipids

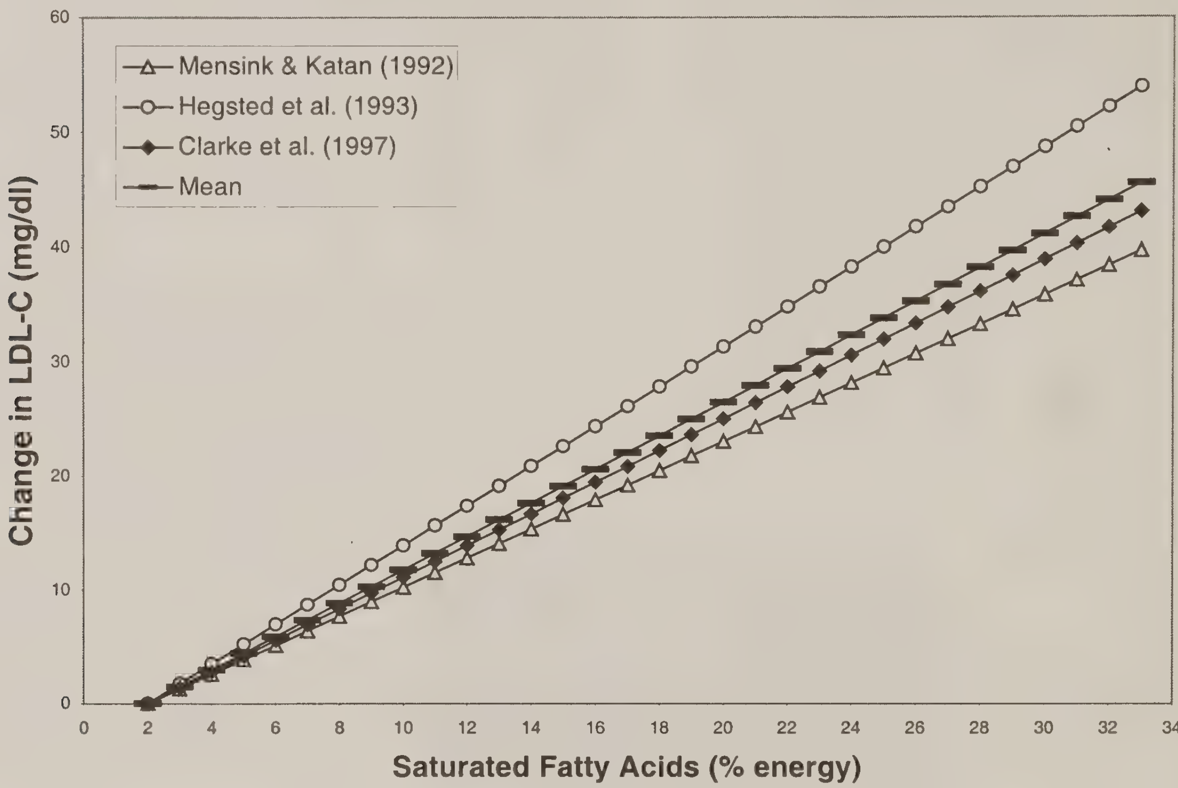
Summaries of evidence for a positive dose-response relationship between saturated fat intake and LDL cholesterol appear in Figures D4-1 through D4-3 shown below and in Table 11-2 of the IOM report (IOM, 2002).

Figure D4-1. IOM Figure 8-2: Relationship Between Serum Total Cholesterol Concentrations and Saturated Fatty Acid Intake



Source: IOM (Institute of Medicine). Dietary Reference Intakes: Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: National Academies Press, 2002.

Figure D4-2. IOM Figure 8-3: Calculated Changes in Serum LDL Cholesterol Concentration in Response to Percent Change in Dietary Saturated Fatty Acids



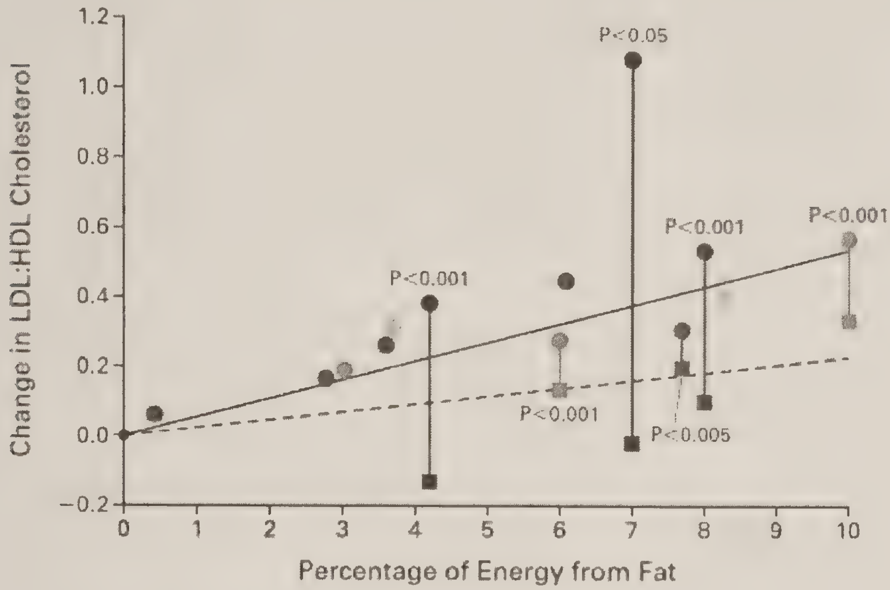
Three regression equations were used to establish the response curves. The range in saturated fatty acid intake was 2.2 to 33 percent of energy.

Source: IOM (Institute of Medicine). Dietary Reference Intakes: Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: National Academies Press, 2002.

Figure D4-1 represents data from a meta-analysis of 395 dietary experiments among 129 groups of individuals and displays the relationship between saturated fat intake and total serum cholesterol concentrations (IOM, 2002). Figure D4-2 plots regression equations for three meta-analyses to show calculated changes in serum LDL cholesterol concentration in response to the change in the percentage of energy provided by saturated fatty acids. The figures show that serum total and LDL cholesterol concentrations increase progressively as saturated fatty acid intake increases. Regression analysis of the data reported in Figure D4-2 demonstrates that for each 1 percent increase in energy from saturated fatty acids, serum LDL cholesterol concentrations increase by 1.3 to 1.8 mg/dl (Clarke et al., 1997; Hegsted et al., 1993; Mensink and Katan, 1992). Over the range of saturated fatty acid intake reported in the literature (2 to 33 percent of energy), serum total and LDL cholesterol concentrations continue to increase. In addition, increasing saturated fatty acid intake increases the LDL:HDL cholesterol ratio progressively (Figure D4-3), which increases CHD risk. The saturated fatty acid-induced increase in the LDL:HDL cholesterol ratio is less than that reported for *trans* fatty acid (see Question 3 for more information about *trans* fatty acids).

The conclusions noted above were further substantiated by recent publications examining the impact of saturated fatty acids on components of the metabolic syndrome. Four clinical trials that replaced saturated fatty acids with MUFAs showed that lipid profiles improved, and some beneficial effects on insulin sensitivity were reported (Heilbronn et al., 1999; Lovejoy et al., 2002; Perez-Jimenez et al., 2001; Vessby et al., 2001).

Figure D4-3. IOM Figure 8-4: Change in the LDL:HDL Cholesterol Concentrations with Increasing Energy Intake from Saturated and *Trans* Fatty Acids



Solid line represents the best-fit regression for *trans* fatty acids. Dotted line represents the best-fit regression for saturated fatty acids.

Source: IOM (Institute of Medicine). Dietary Reference Intakes: Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: National Academies Press, 2002.

Magnitude of Effect

A reduction of one percentage point in energy from saturated fat decreases serum LDL cholesterol about one to two percent, on average (NCEP, 2002). Thus, decreasing saturated fat intake from 12 percent of calories to less than 7 percent of calories would reduce LDL cholesterol by about 8 to 10 percent. An LDL cholesterol lowering response of 8 to10 percent would be expected to reduce the risk of CHD by 8 to 10 percent, since a 1 percent reduction in LDL cholesterol decreases risk for CHD events by approximately 1 percent. This estimate of the magnitude of effect of decreasing saturated fat intake is derived from a large sample population with inherent variation about the mean. For example, there is evidence that the response is greater in individuals with elevated LDL cholesterol levels and that some individuals, especially those who are overweight or obese, are less responsive to dietary saturated fatty acids than expected (Denke, 1995; Schaefer et al., 1997).

The recommendation to decrease saturated fat from about 12 percent of calories (estimated current intake) to less than 7 percent of calories for adults with an LDL cholesterol level ≥ 130 mg/dl would be expected to decrease CHD risk by about 8 to 10 percent. Likewise, if saturated fat intake were decreased from 12 percent of calories to 9 percent of calories in adults who have an LDL cholesterol < 130 mg/dl, this 3-percentage point reduction in saturated fat would decrease LDL cholesterol about 4 to 6 percent, resulting in an approximate 5 percent reduction in CHD risk.

Saturated Fats and Cancer

In a meta-analysis of dietary fat and breast cancer risk, the summary relative risk for saturated fat was 1.19 (95 percent CI: 1.06,1.35), based on an analysis of 23 case-control studies and 12 cohort studies (Boyd et al., 2003). The Committee identified two case-control studies published after that meta-analysis was completed. In a study of Korean women that included 224 cases and 240 controls, Do et al. (2003) report that higher breast cancer incidence was not observed with higher saturated fatty acid intake (more than 19.5 g per day). However there was a statistically significant trend of increasing breast cancer incidence with increasing total saturated fatty acid intake. In the Norfolk, UK, center of the *European Prospective Investigation of Cancer*, each of 186 women with breast cancer was matched with four healthy controls (840 total participants). In this study, the risk of breast cancer was strongly associated with the amount of saturated fat

consumed. Women who consumed more than 35 g per day of saturated fat had more than twice the risk of developing breast cancer than that of women who consumed 10 g per day or less of saturated fat (Bingham and Riboli, 2004).

Nutrients Provided by Diets Very Low in Saturated Fats

Results of menu modeling activities (IOM, 2002) indicate that diets can be planned to meet nutrient recommendations for linoleic acid and α-linolenic acid while providing very low amounts of saturated fatty acid (3 to 5 percent of calories from saturated fatty acid). ATP III has 10 different menu simulations for different ethnic and gender groups that meet the recommendations of the therapeutic lifestyle changes diet (NCEP, 2002, Diet Appendix B). That diet recommends less than 7 percent of calories from saturated fat, less than 200 mg of cholesterol per day, 1 to 2 g of stanol/sterol esters[3] per day and 10 to 25 g per day of soluble fiber. In addition, weight control and daily physical activity are recommended. In these simulations, the saturated fatty acid content of the diet can be as low as 4 to 6 percent of calories.

Positions Taken by Other Expert Groups—Using an evidence-based approach, the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults published the following evidence statement and recommendation related to saturated fat:

> ***Evidence Statement***
> There is a dose response relationship between saturated fatty acids and LDL cholesterol levels. Diets high in saturated fatty acids raise serum LDL cholesterol levels. Reduction in intakes of saturated fatty acids lowers LDL cholesterol levels. High intakes of saturated fatty acids are associated with high population rates of CHD. Reduction in intake of saturated fatty acids will reduce risk for CHD.
>
> ***Recommendation***
> The therapeutic diet to maximize LDL cholesterol lowering should contain less than 7 percent of total calories as saturated fatty acids.
> (National Cholesterol Education Program Expert Panel, 2002, p. V-4)

[3] Plant sterols are isolated from soybean and tall pine-tree oils. Plant sterols can be esterified to unsaturated fatty acids, creating sterol esters. Hydrogenating sterols produces plant stanols and, with esterification, stanol esters (NCEP, 2002).

In addition, an evidence-based technical report of the American Diabetes Association included the following statement for saturated fat and diabetes:

> Less than 10 percent of energy intake should be derived from saturated fats.
>
> To lower LDL cholesterol, energy derived from saturated fat can be reduced if weight loss is desirable or replaced with either carbohydrate or monounsaturated fat when weight loss is not a goal.
> (Franz et al., 2004, p. S39)

ATP III has defined the following categories for LDL cholesterol values (NCEP, 2002):

- Optimal: < 100 mg/dl
- Near optimal/above optimal: 100 to 129 mg/dl
- Borderline high: 130 to 159 mg/dl
- High: 160 to 189 mg/dl
- Very high: ≥ 190 mg/dl

Recently, NCEP revised these recommendations (Grundy et al., 2004c). In high-risk persons, the recommended LDL cholesterol goal is less than 100 mg/dl; but when risk is very high, an LDL cholesterol goal of less than 70 mg/dl is a therapeutic option. When risk is moderately high, the recommended LDL cholesterol goal is less than 130 mg/dl, but an LDL cholesterol goal of less than 100 mg/dl is a therapeutic option. This more rigorous LDL cholesterol goal likely will require pharmacologic therapy in combination with the dietary changes.

For all adults, including those with an LDL cholesterol concentration less than 130 mg/dl, the risk of heart disease continues to decrease progressively as LDL cholesterol decreases. Clinical trials demonstrate the efficacy of LDL-cholesterol lowering as an important means of reducing the risk of CHD. Consequently, risk is decreased the most when LDL is decreased most.

Saturated Fatty Acids and the Health of Children

Research on the impact of saturated fatty acid consumption in healthy children is lacking.

Stearic Acid

Stearic acid has attracted interest as a substitute for *trans* fatty acids in prepared foods that require a solid fat. Stearic acid offers the functional properties needed for these foods, but the question arises of how it affects blood lipid values. Stearic acid is a unique saturated

fatty acid with respect to its effects on blood lipids and lipoproteins. Stearic acid has been shown to have a neutral effect on serum total and LDL cholesterol concentrations (Bonanome and Grundy, 1988; Denke, 1994; Hegsted et al., 1965; Keys, 1965; Yu et al., 1995; Zock and Katan, 1992). A meta-analysis of 35 studies suggests that stearic acid has a minimal effect on LDL cholesterol and no effect on HDL cholesterol (Mensink et al., 2003). In contrast, the other long chain saturated fatty acids increase both LDL cholesterol and HDL cholesterol (Mensink et al., 2003).

Because of the growing interest in stearic acid as a substitute for *trans* fatty acids in solid fats, there is a need to assess the effects of this fatty acid on cardiovascular disease (CVD) risk factors beyond blood lipids and lipoproteins. Only one published study provides evidence about the effects of stearic acid on other CVD endpoints. In particular, Baer et al. (2004) designed a study to evaluate the effects of individual fatty acids on hemostatic risk factors for CVD. Compared with diets that provided 2 to 3 percent of calories from stearic acid, a diet that provided 8 percent of calories from stearic acid increased fibrinogen concentration by 4.4 percent. This translates to an approximate 7 percent increase in the risk of myocardial infarction. This study also compared the hemostatic effects of a diet that provided 4 percent of calories from stearic acid plus 4 percent of calories from *trans* fats with those of a high-carbohydrate (54.6 percent of calories from carbohydrate) control diet. In this comparison, there was no effect on fibrinogen concentration. Typical consumption of stearic acid in the United States is approximately 3.5 percent of calories. Thus, at intakes of stearic acid that are equal to or slightly higher than amounts consumed in the United States, no adverse effects on fibrinogen levels would be expected.

Saturated Fat Intake

Based on data from NHANES III and 1999–2000, reported saturated fat intake by Americans is as follows:

- For all ages of the U.S. population over 2 months, the daily mean percentage of calories from saturated fat was 11.2 percent. In 1999–2000, 41 percent of the population age 2 years and older reported intakes of less than 10 percent of calories from saturated fat (Briefel and Johnson, 2004).
- Adult women, persons age 60 and older, Hispanics, and persons with higher household income were more likely than others to have intakes of less than 10 percent of calories from saturated fat (Briefel and Johnson, 2004).
- Among adults age 20 to 74 years, mean saturated fat intake decreased from 13 percent of calories in 1971–1974 to 11 percent of calories in 1999–2000 (Briefel and Johnson, 2004).
- For persons age 2 to 19 years, mean saturated fat intake was 12.2 percent of energy (Troiano et al., 2000).
- Mean saturated fat intake ranged from 11.6 percent of energy for females age 12 to 15 years to 12.8 percent for males age 6 to 8 years. Mean saturated fat intake ranged from 11.7 percent of calories for non-Hispanic white females age 12 to 19 years to 12.8 percent for Mexican American males age 6 to 11 years. (Troiano et al., 2000)

Using data from CSFII, 1994–1996, Gleason and Suitor (2001) found that mean usual intake of saturated fat was 12 percent of calories among school-age children.

In summary, current saturated fat intake is approximately 11 to 13 percent of calories. This represents a 1- to 2-percentage point decrease since the early 1970s for the population at large. Some population groups are consuming less than 10 percent of calories from saturated fat.

Question 3: What Are the Relationships Between *trans* Fat Intake and Health?

Conclusion

The relationship between *trans* fatty acid intake and LDL cholesterol is direct and progressive, increasing the risk of CHD. *Trans* fatty acid consumption by all population groups should be kept as low as possible, which is about 1 percent of energy intake or less.

Rationale

Overview

This conclusion is supported by a systematic, extensive review of the evidence conducted by the IOM (2002) covering 20 controlled trials and 11 epidemiologic studies; the evidence-based review conducted by the NCEP Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (2002); and the Committee's review of 7 more recent publications.

Summaries of evidence of relationships of *trans* fatty acid intake and health from the IOM report (IOM, 2002) appear in Tables 8-9 through 8-13 of that report and in Figure D4-3. Those tables cover the following topics:

- Table 8-9: Dietary *trans* Fatty Acids and Blood Lipid Concentration: Controlled Feeding Trials
- Table 8-10: Hydrogenated Fat Intake and Blood Lipid Concentrations: Controlled Feeding Trials
- Table 8-11: Dietary *trans* Fatty Acids, Hydrogenated Fat, and Blood Lipids Concentrations: Free Living Trials
- Table 8-12: *trans* Fatty Acid Intake and Blood Clotting, Blood Pressure, and Low-Density Lipoprotein Oxidation
- Table 8-13: Dietary *trans* Fatty Acids: Epidemiologic Studies

Review of the Evidence

Trans Fatty Acids and Blood Lipids—The data reported in Tables 8-9 and 8-10 of the IOM report summarize 12 controlled feeding studies, and the data in Table 8-11 summarize 7 trials with subjects consuming self-selected diets (IOM, 2002). These data show that, when compared with unsaturated fatty acids, *trans* fatty acids/hydrogenated fat increase LDL cholesterol concentrations. In addition, when *trans* fatty acids are substituted for saturated fatty acids, HDL cholesterol concentration decreases; and a dose-response effect is observed. There is a progressive dose-dependent relationship between *trans* fatty acid intake and an increase in the LDL:HDL cholesterol ratio (Figure D4-3). This observed relationship is progressive over the range of *trans* fat intake from 0.5 to 10 percent of calories. The magnitude of this effect is greater for *trans* fatty acids than for saturated fatty acids. The saturated fatty acids increase HDL cholesterol, albeit modestly, even when comparisons are made at low levels of saturated fat intake, but the dose-response relationship for *trans* fatty acid intake and the LDL:HDL cholesterol ratio begins to become greater than that observed for saturated fatty acids at about 2.5 percent of energy intake.

Recent clinical studies support the findings described above: both *trans* fat and saturated fat increase LDL cholesterol similarly; however, saturated fat increases HDL cholesterol whereas *trans* fat does not (Judd et al., 2002; Lovejoy et al., 2002). Several of the recent studies have shown that replacing saturated fats with *trans* fat decreases serum HDL cholesterol (de Roos et al., 2001, 2002, 2003). A meta-analysis of 60 controlled trials (Mensink et al., 2003) reported that the consumption of *trans* fat significantly increased the total:HDL cholesterol ratio. Dietary *trans* fatty acids also have been shown to increase small, dense LDL cholesterol proportionately to the amount of dietary *trans* fatty acids (Mauger et al., 2003).

The data reported in Table 8-12 of the IOM report (IOM, 2002) indicate that *trans* fatty acids have little effect on hemostatic factors, susceptibility of LDL cholesterol to oxidation, or blood pressure. Other clinical studies have reported adverse effects of *trans* fatty acids on other CVD risk factors including postprandial lipids (Gatto et al., 2003) and impaired endothelial function (de Roos et al., 2002). Recent epidemiologic evidence from the *Nurses' Health Study I and II* indicates that *trans* fatty acid intake is positively associated with the systemic inflammatory markers for cardiovascular disease, with soluble tumor necrosis factor α receptors 1 and 2 in all women, and with IL-6 and C-reactive protein in women with higher body mass index (Mozaffarian et al., 2004).

Trans Fatty Acids and Cardiovascular Disease—Epidemiologic evidence from 6 cohort studies (Table 8-13, IOM, 2002) suggests that a high *trans* fat intake is associated with an increased risk of coronary artery disease. In an analysis of data from the *Seven Countries Study*, Kromhout et al. (1995) reported strong positive associations between 25-year death rates from CHD and the average intake of the *trans* fatty acid elaidic acid ($r = 0.78$, $p < 0.001$), and the average intake of the four major long-chain saturated fatty acids ($r > 0.8$, $p < 0.001$) and of dietary cholesterol ($r = 0.55$, $p < 0.05$). Hu et al. (1997) reported that intake of *trans* fat was associated with an increased risk of CHD in women. Women in the highest quintile of *trans* fat intake (2.9 percent of energy) had a 27 percent greater risk of CHD than women in the lowest quintile (95 percent CI: 1.03, 1.56, $p = = 0.02$ for trend). In comparison, women in the highest quintile of saturated fat intake had a 16 percent greater risk of CHD than women in the lowest quintile (95 percent CI: 0.93,1.44, $p = 0.04$ for trend). Similar findings were reported by Pietinen et al. (1997). Among men in the top quintile of *trans* fatty acid intake (median = 6.2 g per day), the multivariate relative risk of coronary death was 1.39 (95 percent CI: 1.09,1.78; $p = 0.004$) compared with men in the lowest quintile of intake (median = 1.3 g per day); there was no association between intakes of saturated, monounsaturated, polyunsaturated fatty acids, or dietary cholesterol and the risk of coronary death. In addition, case-control studies demonstrate an

association between *trans* fat intake and the risk of myocardial infarct. For example, compared with the lowest quintile of intake, the relative risk of acute myocardial infarction for the highest quintile of *trans* fatty acid intake was 2.4 (p for trend < 0.0001) (Ascherio et al., 1994).

More recent studies have reported an association between the *trans* fatty acid content of adipose tissue (a biomarker of long-term fatty acid intake) and the risk of nonfatal myocardial infarct (Baylin et al., 2003; Clifton et al., 2004). In the study conducted by Clifton et al., both vegetable and animal *trans* fat contributed to the increased risk. However, other epidemiologic studies report a link only between the intake of hydrogenated vegetable oils and coronary artery disease; the intake of *trans* fatty acids from animal sources had no observed adverse effect (Ascherio et al., 1999, 1996; Willett et al., 1993). Recent evidence, however, suggests that the risk of CHD is similar between total ruminant and industrial *trans* fatty acids for intakes up to 2 g per day (Weggemans et al., 2004). In a case control study (Lemaitre et al., 2002) reported that higher total *trans* fatty acids in red blood cell membranes was associated with a modest increase in the risk of primary cardiac arrest (odds ratio for interquintile range, 1.5; 95 percent CI, 1.0 to 2.1). Notably, higher levels of *trans* isomers of linoleic acid were associated with a 3-fold increase in risk, whereas *trans* isomers of oleic acid were not.

Although intakes of saturated fat, *trans* fat, and cholesterol all should be decreased, because saturated fat consumption is proportionately much greater than that of these other fats, saturated fat should be the primary focus of dietary modification.

Positions Taken by Other Expert Groups—Using an evidence-based approach, the NCEP Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults published the following evidence statement and recommendation related to *trans* fat:

> ***Evidence Statement***
> *Trans* fatty acids raise serum LDL cholesterol levels. Consequently, higher intakes of *trans* fatty acids increase risk for CHD. Prospective studies support an association between higher intakes of *trans* fatty acids and CHD incidence. However, *trans* fatty acids are not classified as saturated fatty acids, nor are they included in the quantitative recommendations for saturated fatty acids intake of < 7 percent of calories in the TLC [Therapeutic Lifestyle Changes] diet.
>
> ***Recommendation***
> Intakes of *trans* fatty acids should be as low as possible. The use of liquid vegetable oil, soft margarine, and *trans* fatty acid-free margarine are encouraged instead of butter, stick margarine, and shortening that contain *trans* fat.
>
> (National Cholesterol Education Program Expert Panel, 2002, p. V-9)

Numerous other expert groups have conducted evidence-based reviews or published consensus statements related to *trans* fatty acids.

> The American Diabetes Association recommends that intake of *trans* unsaturated fatty acids be minimized.
>
> (Franz et al., 2004, p. S39)

> An FDA Food Advisory Committee, Nutrition Committee, recently voted (6 yes, 1 abstain) in favor of the following statement: "Although current scientific evidence does not indicate a specific acceptable daily intake for *trans* fatty acids, it is consistent with reducing *trans* fatty acid intake to a level less than 1 percent of energy (2 g per day for a 2,000-calorie diet)."
>
> (FDA Food Advisory Committee, Nutrition Subcommittee Transcripts. April 28, 2004 p. 92)

> The AHA [American Heart Association] Dietary Guidelines Revision 2000 recommends that *trans* fatty acid intake be limited, and that the total intake of cholesterol-raising fatty acids not exceed 10 percent of energy.
>
> (Krauss et al., 2000, p. 2288)

> An earlier statement issued by the American Heart Association recommended that naturally occurring unhydrogenated oil be used when possible and attempts made to substitute unhydrogenated oil for hydrogenated oil or saturated fat in processed foods. Also, softer margarines should be substituted for harder margarines and cooking fats.
>
> (Lichtenstein, 1997, p. 2590)

The conclusion to keep *trans* fatty acid consumption by all population groups as low as possible also is supported by the World Health Organization Report (WHO) (2003), which recommends < 1 percent of energy from *trans* fatty acids and the Danish Nutrition Council (Stender and Dyerbery, 2003), which recommends that the use of industrially produced *trans* fatty acids in foodstuffs be ceased as soon as possible.

Trans Fatty Acid Intake—Using 1989–1991 CSFII data, the estimated mean *trans* fatty acid intake for the U.S. population age 3 years and older was 2.6 percent of total energy intake (Allison et al., 1999). For individuals age 20 years and older, the estimated average daily intake of *trans* fat in the U.S. population is about 5.8 g per day, which represents about 2.6 percent of total energy intake. Industrial sources provide approximately 80 percent of *trans* fat in the diet, compared to 20 percent from animal sources. The major food sources of *trans* fat for U.S. adults are shown in Table D4-1.

Most *trans* fat comes from industrial sources of fat. However, even if partially hydrogenated fats were removed from the food supply, the Committee estimates that *trans* fats still would provide about 1 percent of the calories because some *trans* fatty acids are produced in the deodorization of vegetable oils (principally as elaidic acid), and meat and dairy products contain naturally occurring *trans* fatty acids as vaccinic acid and conjugated linoleic acid (CLA). There is emerging evidence that the naturally occurring *trans* fatty acids, vaccinic acid, and conjugated linoleic acid, have unique biological effects. In animal studies, CLA can decrease fat deposition and body lipid content (Wang and Jones, 2004). However, the few human studies conducted to date have not demonstrated a similar effect. There is also evidence from animal studies that CLA protects against the development and progression of atherosclerosis (Toomey et al., 2003). Studies with both animals and cell models demonstrate anti-carcinogenic effects of CLA and vaccinic acid for many types of cancer (Banni et al., 2001; Corl et al., 2003; Ip et al., 1999). According to the Food and Drug Administration (*Federal Register* notice, 2003), the average *trans* fat intake from animal sources is 1.2 g per day. This is approximately 0.5 percent of calories, of which conjugated linoleic acid contributes a small quantity (151 to 212 mg per day) (IOM, 2002). *Trans* fat from animal products is estimated to provide less than 1 percent of calories in the revised USDA food intake pattern (Table D1-13). Decreased consumption of foods made with industrial sources of *trans* fats (see plant foods in Table D4-1) provides the most effective means of reducing *trans* fat intake.

Table D4-1. Major Food Sources of *trans* Fat for U.S. Adults

Food Source	**Percent of *trans* Fat Supplied by the Food**
Cakes, cookies, crackers, pies, bread, etc	40
Animal products	21
Margarine	17
Fried potatoes	8
Potato chips, corn chips, popcorn	5
Household shortening	4
Salad dressing	3[a]
Breakfast cereal	1
Candy	1

[a] USDA analysis reported 0 grams of *trans* fat in salad dressing.

Source: Based on the Food and Drug Administration's economic analysis for the final *trans* fatty acid labeling rule, *trans Fatty Acids in Nutrition Labeling, Nutrient Content Claims, and Health Claims* (68 *Federal Register:* 41443 [July 11, 2003]).

Question 4: What Are the Relationships Between Cholesterol Intake and Cardiovascular Disease?

Conclusion

The relationship between cholesterol intake and LDL cholesterol concentrations is direct and progressive, increasing the risk of CHD. Thus, cholesterol intake should be kept as low as possible within a nutritionally adequate diet. In particular,

- For adults with an LDL cholesterol < 130 mg/dL, less than 300 mg of dietary cholesterol per day is recommended.
- For adults with an elevated LDL cholesterol (≥ 130 mg/dL), less than 200 mg of dietary cholesterol/day is recommended.

Rationale

Overview

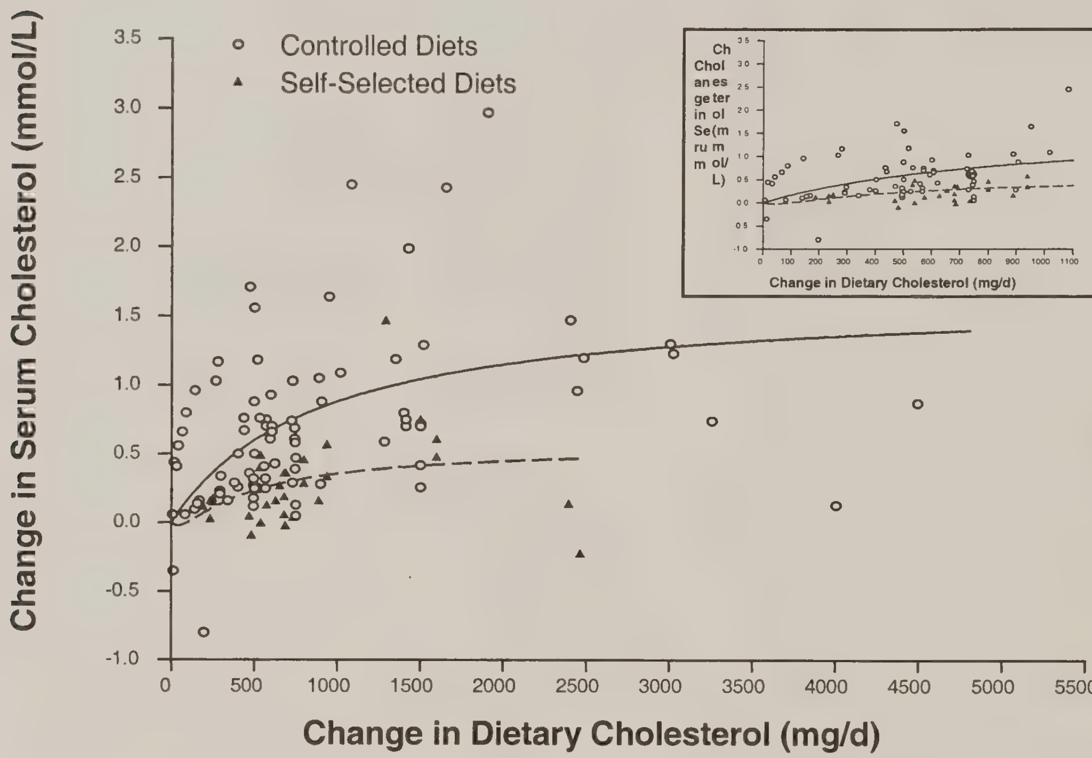
This conclusion is supported by evidence from a systematic, extensive review of the scientific literature by the IOM (2002) covering 49 controlled trials and 14 observational studies; the evidence-based review conducted by the NCEP Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (2002); and the Committee's review of 5 more recent controlled trials.

Summaries of evidence of effects of dietary cholesterol on serum cholesterol and CHD from the IOM report (IOM, 2002) appear in Tables 9-2 through 9-4 of that report and Figure D4-4 below. The tables cover the following topics:

- Table 9-2: Effects of Adding Dietary Cholesterol to Defined Diets with Strict Control of Dietary Intake on Serum Cholesterol Concentrations
- Table 9-3: Effects of Adding Dietary Cholesterol to Self-Selected Diets with Strict Control of Dietary Intake on Serum Cholesterol Concentrations
- Table 9-4: Dietary Cholesterol and Coronary Heart Disease

There is a historical basis for the cholesterol recommendation that dates back to 1968 when the American Heart Association recommended about ~300 mg per day to decrease the risk of CHD (American Heart Association, 1968). In 1977 the Dietary Goals for the United States recommended that dietary cholesterol be reduced to 300 mg per day (U.S. Senate, 1977). Since then, the scientific evidence has supported this recommendation and the more contemporary guidance that dietary cholesterol intake be decreased further in persons with elevated LDL cholesterol (Dixon and Ernst, 2001).

Figure D4-4. IOM Figure 9-2: Relationship Between Change in Dietary Cholesterol (0 to 4500 mg/day) and Change in Serum Cholesterol Concentration



Source: IOM (Institute of Medicine). Dietary Reference Intakes: Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: National Academies Press, 2002.

Review of the Evidence

Dietary Cholesterol and Serum Cholesterol— The data summarized in the tables cited above show that, in most studies, as dietary cholesterol increases there is a corresponding increase in total serum cholesterol. A meta-analysis (Figure D4-4) of 27 controlled metabolic feeding studies of added dietary cholesterol indicates a relationship with change in serum cholesterol that is steeper in the range from zero to 300 to 400 mg per day of added dietary cholesterol and less steep above this level. However, data summarized in Table 9-4 of the IOM report (IOM, 2002) covering 15 observational studies, show a lack of consistency in epidemiologic observations relating dietary cholesterol to clinical CVD and CHD endpoints. The inconsistent findings may be due to limited power to detect effects (e.g., relatively small increases in LDL cholesterol concentration and inaccuracy in dietary intake data), limited power to distinguish the effects of dietary cholesterol independent of other factors (such as saturated fat, energy intake, and fiber intake), or other factors.

The Committee's conclusion concurs with the recommendation for cholesterol intake made by the IOM, which is to decrease cholesterol intake as much as possible within the context of a nutritionally adequate diet (IOM, 2002). The IOM recommendation is supported by evidence from a systematic, extensive review of the scientific literature. The specific recommendation for less than 200 mg per day is consistent with the evidence-based recommendation for individuals with an LDL cholesterol greater than 130 mg/dl made by ATP III (NCEP, 2002).

Magnitude of Effect—Based on a meta-analysis of 27 controlled feeding studies (Hopkins, 1992), for a baseline cholesterol intake of zero, the estimated increase in serum cholesterol is 5 mg/dl per 100 mg of added dietary cholesterol per day—up to 400 mg of cholesterol per day. In contrast, when baseline cholesterol intake is 300 mg per day, the estimated increase in serum cholesterol is 1.5 mg per day in response to the addition of 100 mg of dietary cholesterol per day (Hopkins, 1992). Equations based on data from numerous studies predict that

100 mg of added dietary cholesterol per day will increase serum cholesterol by 2 to 3 mg/dl (Clarke et al., 1997; Hegsted, 1986; Howell et al., 1997). Of this increase in total serum cholesterol, approximately 80 percent is in the LDL fraction. For an individual with a total serum cholesterol level of 200 mg/dl, a 2 to 3 mg increase represents an approximate 1 to 1.5 percent increase in serum cholesterol level (equivalent to a 0.8 to 1.2 percent increase in LDL cholesterol). This increase would be expected to increase CHD risk about 1 percent (IOM, 2002; NCEP, 2002). Notably, however, the effect of added cholesterol is variable among individuals ranging from essentially no response to a greater response. For example, a recent study has shown that both normal weight and overweight/obese individuals who are insulin resistant seem to have a diminished response to dietary cholesterol compared with insulin sensitive individuals (Knopp et al., 2003). Based on the collective evidence, the magnitude of overall response to dietary cholesterol is much less than that observed for saturated and *trans* fat intake.

Positions Taken by Other Expert Groups—Using an evidence-based approach, the NCEP Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults published the following evidence statement and recommendation related to cholesterol:

> ***Evidence Statement***
> Higher intakes of dietary cholesterol raise serum LDL cholesterol levels in humans. Through this mechanism, higher intakes of dietary cholesterol should raise the risk for CHD. Reducing cholesterol intakes from high to low decreases serum LDL cholesterol in most persons.
>
> ***Recommendation***
> Less than 200 mg per day of cholesterol should be consumed in the TLC [Therapeutic Lifestyle Changes] Diet to maximize the amount of LDL cholesterol lowering that can be achieved through reduction in dietary cholesterol.
> (National Cholesterol Education Program Expert Panel, 2002 p. V-4)

Using an evidence-based approach, the American Diabetes Association published the following evidence-based nutrition principle and recommendation related to cholesterol:

> Dietary cholesterol intake should be < 300 mg per day. Some individuals (i.e., persons with LDL cholesterol ≥ 100 mg/dl) may benefit from lowering dietary cholesterol to <200 mg per day.
> (Franz et al., 2004, p. S39)

Dietary Cholesterol and Children's Health—Research on the impact of dietary cholesterol consumption on LDL cholesterol and other CVD risk factors in healthy children is lacking.

Cholesterol Intake—Mean cholesterol intake is above the recommended level of 300 mg per day for adult males and below it for adult females. For adults age 20 to 74, age-adjusted mean dietary cholesterol intake was 341 mg in men and 242 mg in women (1999–2000) (Briefel and Johnson, 2004). Troiano et al. (2000) found an increase in cholesterol intake with age for young males, reaching a peak of 375 mg at age 16 to 19 years. Among males age 12 to 19 years, the mean (but not median) intake exceeded 300 mg regardless of racial/ethnic group. Among females, the highest mean intake (233 mg) occurred at age 9 to 11 years.

Question 5: What Are the Relationships Between n-6 PUFA Intake and Health?

Conclusion

An n-6 PUFA intake between 5 to 10 percent of energy may confer beneficial effects on coronary artery disease mortality.

Rationale

Overview

The conclusion regarding the range of intake of n-6 PUFAs is based on the IOM's AMDR for this fatty acid class (IOM, 2002). Evidence concerning beneficial effects on coronary artery disease mortality was obtained from the same IOM report and a systematic review of 17 published papers.

The n-6 PUFAs include linoleic acid, which accounts for about 85 percent to 90 percent of the total PUFA consumption, and arachadonic acid, which contributes less than 2 percent of the total (IOM, 2002). A dietary source of linoleic acid is essential for life and health. Linoleic acid serves as a precursor to eicosanoids. A lack of dietary n-6 PUFAs is characterized by rough, scaly skin;

dermatitis; and an elevated eicosatrienoic acid to arachidonic acid (triene:tetraene) ratio. The IOM (IOM, 2002) set an AI for linoleic acid of 17 g per day for men and 12 g per day for women. It also set an AMDR for linoleic acid of 5 to 10 percent of calories (IOM, 2002). The lower end of the range meets the AI for linoleic acid. The upper end of the range was based on three lines of evidence: (1) individual dietary intakes in a North American/U.S. population rarely exceed 10 percent of energy, (2) epidemiologic evidence for the safety of intakes greater than 10 percent of energy generally are lacking, and (3) high intakes of linoleic acid create a pro-oxidant state that may predispose to several chronic diseases, such as CHD and cancer.

Review of the Evidence

n-6 Fatty Acid Intake and Blood Lipids— Evidence from six intervention studies was provided in the IOM report (IOM, 2002, see Table 11-9: *Interventional Studies on n-6 Fatty Acid Intake and Blood Lipid Concentrations*). The studies included in the table demonstrate that higher n-6 polyunsaturated fatty acid intake generally is associated with a more favorable CHD lipid risk profile.

n-6 Fatty Acid Intake and CVD—A number of epidemiologic studies have examined the association between n-6 PUFA intake and CVD. In two population studies (Artaud-Wild et al., 1993; Hegsted and Ausman, 1988), PUFA intake was negatively associated with CVD mortality after adjusting for dietary saturated fat. Several prospective studies (Ascherio et al., 1996; Garcia-Palmieri et al., 1980; Gordon et al., 1981; Hu et al., 1997; Shekelle et al., 1981), two longitudinal studies (Joossens et al., 1989; Tell et al., 1994), and one cross-sectional study (Djousse et al., 2001) reported a beneficial association of dietary PUFAs with CVD morbidity and mortality (Table D4-2). In contrast, no significant association was found between dietary PUFAs and CVD in the *Seven Countries Study* (Keys, 1997; Kromhout et al., 1995). Similarly, other epidemiologic studies did not find a beneficial association between PUFAs and CVD (Kark et al., 2003; Kushi et al., 1985; Posner et al., 1991).

Adverse Effects of PUFA—In a systematic review of research, the Committee found no studies that reported adverse effects, even in the *Jerusalem Study* in which 25 percent of the population had PUFA intakes that exceeded 12 percent of calories (Kark et al., 2003). However, as noted previously, the upper end of the AMDR took into account that the epidemiologic evidence for the safety of intakes greater than 10 percent of energy generally are lacking and that high intakes of linoleic acid may create a pro-oxidant state (IOM, 2002).

Positions Taken by Other Expert Groups— This conclusion also was supported by the evidence-based *Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults.*

> ***Evidence Statements***
> Linoleic acid, a polyunsaturated fatty acid, reduces LDL cholesterol levels when substituted for saturated fatty acids in the diet. Polyunsaturated fatty acids also can cause small reductions in HDL cholesterol when compared with monounsaturated fatty acids, especially when present in high amounts in the diet. Controlled clinical trials indicate that substitution of polyunsaturated fatty acids for saturated fatty acids reduces risk for CHD.
>
> ***Recommendation***
> Polyunsaturated fatty acids are one form of unsaturated fatty acids that can replace saturated fat. Most polyunsaturated fatty acids should be derived from liquid vegetable oils, semi-liquid margarines, and other margarines low in trans fatty acids. Intake of polyunsaturated fat can be as high as 10 percent of total calories.
> (National Cholesterol Education Program Expert Panel, 2002, p. V-11)
>
> Using an evidence-based approach, the American Diabetes Association published the following evidence-based nutrition principle and recommendation related to PUFAs:
>
> Polyunsaturated fat intake should be ≈ 10 percent of energy intake.
> (Franz et al., 2004, p. S39)

n-6 PUFA Intake—Mean n-6 PUFA intakes by Americans fall within the AMDR. Based on CSFIII 1989-91 data, mean intakes by adults are approximately 5 to 6 percent of total energy intake (Allison et al., 1999). Using NHANES III data, mean intakes by children and adolescents ranged from about 6 to nearly 8 percent, depending on the age and ethnic group (Troiano et al., 2000).

Table D4-2. Correlation Coefficients Between Dietary Polyunsaturated Fat (PUFA) Intake and Coronary Artery Disease Mortality and Relative Risk or Cases

Study	Years of Follow-up	Diet Assessment Methods	Number of Subjects	Number of Subjects With Coronary Artery Disease	PUFA Intakes Percent Energy	PUFA Correlation Coefficients	Relative Risk or Cases
Cross-population studies							
Seven Countries, Study, Keys, 1970	1958–1964 (5 year)	7-day weighed record, composite analysis (subsample)	12,770	---	3 to 7 percent	NS	---
Eighteen Countries Study, Hegsted and Ausman, 1988	1954–1965, 1973	Food disappearance statistics	---	---	1.4 to 10.9 percent	-0.34	CHD mortality predicted by SFA and PUFA intake (r=0.79) -0.33[2] After adjustment for cholesterol and SFA
Forty Countries Study, Artraud-Wild et al., 1993	1957–1977, 1977	Food disappearance statistics	---	---	---	---	
Seven Countries Study, Kromhout et al., 1995	25 year	Retrospectively constructed food composites (n=498)	12,763	~1,900 deaths	3.4 to 8.6 percent	n-6: 0.0 n-3: -0.36	---
Within-population studies							
Puerto Rico Heart Health Program, Garcia-Palmieri et al., 1980	Prospective 6 year	24-hour recall	8,218 men	73 (rural) 213 (urban)	4 percent (rural) 6.6 percent (urban)	---	11 vs 10[9] cases 16 vs 17 cases
Three Populations Study, Gordon et al., 1981	Prospective 4 year Framingham	24-hour recall	859 men	79	5.7 percent	---	5.4 vs 5.8[10]
	Prospective 6 year Honolulu Heart	24-hour recall	7,272 men	264	5.6 percent	---	6.0 vs 6.7[3]
	Prospective 6 year Puerto Rico Heart Health	24-hour recall	8,218 men	286	6.4 percent	---	5.3 vs 6.0[3]
Western Electric Study, Shekelle et al., 1981	Prospective 19 year	Diet history	1,900 men	---	3.9 percent	-0.258[3]	Low—13.5[8] Mid—10.4 High—10.1

Table D4-2 (cont.). Correlation Coefficients Between Dietary Polyunsaturated Fat (PUFA) Intake and Coronary Artery Disease Mortality and Relative Risk or Cases

Study	Years of Follow-up	Diet Assessment Methods	Number of Subjects	Number of Subjects With Coronary Artery Disease	PUFA Intakes Percent Energy	PUFA Correlation Coefficients	Relative Risk or Cases
Honolulu Heart Prgm., McGee et al., 1984	Prospective 10 year	24-hour recall	7,088 men	456	6 percent	---	0.093[11]
Ireland-Boston Diet-Heart Study, Kushi et al., 1985	Prospective 20 year	Diet history	1,001 men	102 deaths	2.1–3.4 percent	-0.0695	---
Belgium Study, Joossens et al., 1989	Longitudinal (1980–1984)	24-hour recall	21,500 men and women	---	14 to 27 g/d	Men –0.73[4] Women –0.41[3]	---
Framingham Study, Posner et al., 1991	Prospective 16 year	24-hour recall	420 men (44–55 y)	99	5.5 percent	0.065	RR = 1.34
Framingham Study, Posner et al., 1991	Prospective 16 year	24-hour recall	393 men (≥55 y)	114	5.4 percent	0.051	RR = 1.27
ARIC Study, Tell et al., 1994	Longitudinal (1987–1989)	Semiquantitative food frequency	2,095 BF 5,146 WF 1,319 BM 4,589 WM	(Carotid artery thickness)	5 percent BF 5.1 percent WF 4.8 percent BM 5.1 percent WM	---	-0.003BF[5] -0.007 WF -0.012 BM -0.011 WM
Health Professionals Follow-up Study, Ascherio et al., 1996	Prospective 6 year	Food frequency questionnaire	43,757	734 coronary events	7.6 to 15.4 g/day	---	MI = NS Fatal CHD = 0.58[12]
Nurses' Health Study, Hu et al., 1997	Prospective 14 year	Semiquantitative food frequency	80,082	939 nonfatal MI or CHD death	2.9 percent 3.9 percent 4.6 percent 5.3 percent 6.4 percent	---	1.0[13] 0.94 0.88 0.81 0.68
NHLBI Family Heart Study, Djousse et al., 2001	Cross-sectional	Semiquantitative food frequency	4,584	566 were at high risk of CAD	3.97 g/d 6.76 g/d 11.68 g/d	---	1.0[14] 0.6 0.61

Table D4-2 (cont.). Correlation Coefficients Between Dietary Polyunsaturated Fat (PUFA) Intake and Coronary Artery Disease Mortality and Relative Risk or Cases

Study	Years of Follow-up	Diet Assessment Methods	Number of Subjects	Number of Subjects With Coronary Artery Disease	PUFA Intakes Percent Energy	PUFA Correlation Coefficients	Relative Risk or Cases
Jerusalem Acute MI Registry, Kark et al., 2003	Cross-sectional	Diet food frequency instrument	672	180	10 percent 90 percent had > 6 percent 25 percent had > 12 percent	NS	OR = 0.96

Notes:
[1]ARIC, Atherosclerosis Risk in Communities; BF, black females; WF, white females; BM, black males; WM, white males.
[2] $p < 0.05$.
[3] $p < 0.01$.
[4] $p < 0.001$.
[5]Scaled difference in carotid wall thickness; p+0.056 WM.
[6]Correlation of Keys score: 0.027 ($p < 0.001$); correlation for Hegsted equation: 0.029 ($p < 0.01$).
[7]Correlation of Keys score: 0.025 ($p < 0.05$); correlation for Hegsted equation: 0.01 ($p < 0.05$).
[8]Percent of coronary death according to tertile of PUFA intakes.
[9]Non-cases vs cases.
[10]PUFA intake for noncases vs cases.
[11]Multivariate logistic coefficient for CHD.
[12] $p < 0.05$ for multivariate adjusted relative risk.
[13] p for trend = 0.003.
[14]Prevalence odds ratio for CAD.
Source: Adapted from Cagguila and Mustad, 1997.

Question 6: What Are the Relationships Between n-3 Fatty Acid Intake and Health?

Conclusion

An α-linolenic acid intake between 0.6 to 1.2 percent of calories will meet requirements for this fatty acid and may afford some protection against CVD outcomes.

The consumption of two servings (approximately 8 ounces) per week of fish high in EPA and DHA is associated with reduced risk of both sudden death and CHD death in adults. To benefit from the potential cardioprotective effects of EPA and DHA, the weekly consumption of two servings of fish, particularly fish rich in EPA and DHA, is suggested. Other sources of EPA and DHA may provide similar benefits; however, further research is warranted.

Rationale

α-Linolenic Acid

Overview—The conclusion regarding the range of intake of α-linolenic acid is based on the IOM's AMDR for this fatty acid (IOM, 2002). Evidence concerning protection against CVD outcomes was obtained from the same IOM report, several more recent studies, and data from the evidence-based report from the HHS Agency for Health Care Policy and Research (AHRQ) entitled *Effects of Omega-3 Fatty Acids on Cardiovascular Disease* (Wang et al., 2004).

A dietary source of α-linolenic acid is essential for life and health. The IOM (IOM, 2002) set an AI for α-linolenic acid of 1.6 g per day for men and 1.1 g per day for women. This represents approximately 0.6 percent of energy intake for sedentary adults. The AMDR for α-linolenic acid is 0.6 percent to 1.2 percent of calories. The lower boundary of the recommended range meets the AI for α-linolenic acid. The AI for α-linolenic acid is based on the median intakes in the United States and Canada—countries in which an α-linolenic acid deficiency is nonexistent in healthy individuals. The upper boundary corresponds to the highest reported α-linolenic acid intake from foods consumed by individuals in the United States and Canada.

Evidence Relating to Cardiovascular Disease—The IOM (2002, pp 11-1 to 11-2) stated, "A growing body of literature suggests that higher intakes of α-linolenic acid, EPA, and DHA may afford some degree of protection against CHD." In addition, the recently released AHRQ report (Wang et al., 2004) also supports the conclusion that α-linolenic acid intakes within the AMDR range of 0.6 percent to 1.2 percent of calories may afford some protection against cardiovascular disease outcomes. Both reports summarized the three epidemiologic studies conducted in the United States that demonstrated that an α-linolenic acid intake of 0.53 to 2.8 g per day reduced the risk of cardiovascular disease events (Djousse et al., 2001), fatal ischemic heart disease (Hu et al., 1999), and all-cause mortality (Dolecek, 1992). In addition, both reports summarized two secondary prevention randomized controlled clinical trials (de Lorgeril et al., 1999; Singh et al., 1997) that demonstrated a beneficial effect of α-linolenic acid on cardiovascular events in post-myocardial infarct patients. These studies reported that increased α-linolenic acid intake (2.0 g per day and 2.9 g per day, respectively) reduced the risk of recurrent coronary events. These α-linolenic acid intake values correspond to approximately 0.8 and 1.2 to 1.3 percent of calories, respectively—values that fall within and slightly above the upper range of the AMDR for α-linolenic acid. In these two studies, the control group consumed 0.27 percent of energy and 0.8 g per day as α-linolenic acid, respectively.

In a primary prevention study on CVD outcomes in a population with a high habitual fish intake conducted in Norway more than 30 years ago, a diet that provided 5.5. g per day of α-linolenic acid from linseed oil did not improve outcomes compared with a diet that provided 0.14 g per day of α-linolenic acid from sunflower seed oil (Natvig et al., 1968). Notably, the two diets differed in other ways related to the unique fatty acid profiles of linseed oil and sunflower oil. Another primary prevention trial in subjects with multiple CVD risk factors (Bemelmans et al., 2002) determined the 10-year estimated ischemic heart disease risk in subjects followed for 2 years. The trial found no effect of a diet that provided 6.3 g per day of α-linolenic acid compared with a diet that provided 1 g per day of α-linolenic acid. Possible reasons to explain a lack of effect of these primary prevention studies may relate to study duration and sample size, neither of which may have been sufficient to test the hypothesis adequately. In addition, in the Natvig et al. study (1968), the high habitual fish intake of the Norwegian population could have blunted an α-linolenic acid effect. In the Bemelmans et al. study (2002), the "low" α-linolenic acid intake group may have consumed a level of α-linolenic acid sufficient to achieve a

beneficial response that was comparable to the response of the high-intake group.

There is no evidence of a beneficial effect of α-linolenic acid intake on the incidence of stroke. Collectively, the evidence supports the hypothesis that the consumption of α-linolenic acid reduces all-cause mortality and various CVD events. However, the evidence is strongest for fish or fish oil supplements, as discussed below.

Evidence Relating to Cancer—A meta-analysis of nine cohort and case-control studies evaluated the relationship between α-linolenic acid and prostate cancer (Brouwer et al., 2004). In this analysis, the intake of α-linolenic acid or the concentration of α-linolenic acid in the blood was used to assess the relative risk of prostate cancer. The results of the individual studies were variable. Based on meta-analysis, however, the relative risk of prostate cancer was higher in the men with the highest intakes or highest blood concentrations of α-linolenic acid than in men with the lowest intakes. The mean α-linolenic acid intake in the highest intake group was 2.0 g per day, and it was 0.8 g per day in the lowest intake group. Of the four prospective studies evaluated in the meta-analysis, two assessed the intake of α-linolenic acid, and two evaluated blood values of α-linolenic acid. In the two that assessed intake, one reported a slight protective effect of α-linolenic acid intake for prostate cancer incidence (RR 0.76; 95 percent CI: 0.66, 1.04) (Schuurman et al., 1999). In contrast, the *U.S. Health Professionals' Follow-Up Study* reported a slightly increased risk of prostate cancer with increasing α-linolenic acid intake (RR 1.25; 95 percent CI: 0.82, 1.92) (Giovannucci et al., 1993).

In a follow-up to the Giovannucci et al. study, α-linolenic acid intake was unrelated to the risk of total prostate cancer among 2,965 new documented cases of total prostate cancer, of which 448 were advanced prostate cancer (Leitzmann et al., 2004). However, the multivariate relative risks of advanced prostate cancer from the extreme quintiles of α-linolenic acid intake from nonanimal sources were 2.02 (95 percent CI: 1.35, 3.03, p for trend 0.0004); and from meat and dairy products, the relative risks were 1.53 (95 percent CI: 0.88, 2.66, p for trend 0.06). In this study, the lower and upper quintiles of total α-linolenic acid intake were less than 0.37 percent and more than 0.58 percent of energy, respectively. Of note, the upper quintile of α-linolenic acid intake in the study by Leitzmann et al. (2004) is comparable to the mean α-linolenic acid intake of the U.S. population using 24-hour recall data (NHANES III), suggesting that the food frequency data reported are underestimates of actual intake. If there is an association between α-linolenic acid intake and prostate cancer risk, it likely would be seen at higher intake levels than those reported. At this time, there are insufficient data to reach a conclusion about an association between α-linolenic acid intake and risk of prostate cancer (Astorg, 2004; Attar-Bashi et al., 2004). Thus, further research is warranted to resolve this question.

Positions Taken by Other Expert Groups—WHO (2003) recommends 1 to 2 percent of energy from n-3 PUFAs. The EuroDiet Core report, *Nutrition and Diet for Healthy Lifestyles in Europe* (2001) recommends 2 g of linolenic acid per day plus 200 mg of very long chain n-3 fatty acids per day.

EPA, DHA, and Fish

Overview

The conclusion regarding fish was reached and supported by evidence from an analysis of epidemiologic studies of the cardioprotective effects of fish consumption among healthy populations (Dolecek, 1992; Hu et al., 2002; Mozaffarian et al., 2003; Siscovick et al., 1995) and information from the evidence-based AHRQ Report *Effects of Omega-3 Fatty Acids on Cardiovascular Disease* (Wang et al., 2004). Information in *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids* (IOM, 2002) provided the starting point of the examination of evidence. Although α-linolenic acid can be elongated to form EPA and DHA, this conversion occurs slowly in humans and the conversion rates are incompletely understood. Thus an important source of EPA and DHA is fish that is high in these fatty acids. This is of significance because the evidence indicates that EPA and DHA are responsible for the cardioprotective effects of fish consumption. In addition, there is evidence that the nonmarine n-3 fatty acid, α-linolenic acid, also plays a cardioprotective role.

Because the biological potency of EPA and DHA is much greater than that for α-linolenic acid, the IOM (2002) did not recommend one AMDR for the entire n-3 fatty acid class. Instead, the IOM recommended that up to 10 percent of the AMDR for α-linolenic acid can be consumed as EPA and/or DHA (0.06 to 0.12 percent of energy). No Upper Level (UL) was established for α-linolenic acid (or for the sum of EPA and DHA) mainly because of insufficient data to use the model of

risk assessment to set this value. With respect to health benefits of EPA and DHA, the IOM report notes the following:

> "a growing body of literature suggests that diets higher in EPA and DHA may afford some degree of protection against CHD"
>
> (IOM, 2002, p. S-6)

> "n-3 polyunsaturated fatty acids (eicosapentaenoic acid [EPA] and docosahexaenoic acid [DHA]) have been shown to reduce the risk of CHD and stroke by a multitude of mechanisms"
>
> (IOM, 2002, Chapter 3, pp. 3–5)

> After the release of the IOM report, new evidence was published demonstrating benefits of fish consumption on CVD among U.S. populations
>
> (Hu et al., 2002; Mozaffarian et al., 2003).

Review of the Evidence

The AHRQ report *Effects of Omega-3 Fatty Acids on Cardiovascular Disease* (Wang et al., 2004) summarizes 22 prospective cohort studies that were conducted in many parts of the world including the United States, China, Japan, and countries in the Mediterranean and Northern Europe. Most of the cohorts had several thousand subjects; the range was 272 to 223,170 subjects, with most subjects at least age 40. The background diets of the study populations from other parts of the world differed from those of the U.S. population. Several of the large population studies in the United States included only males or only females, with the study duration ranging from age 4 to 30. Most of the studies used food frequency questionnaires to estimate the dietary fish intake. Most studies provided quantitative estimates of the amount of fish consumed (many also quantified the sum of EPA and DHA intake) and categorized them into various quantiles (e.g., tertiles, quartiles, quintiles). Other studies reported only the frequency of fish consumption or simply whether fish was consumed. Despite some limitations, if viewed together, these studies provide evidence that is highly applicable to the U.S. population. Overall the evidence from the primary and secondary prevention studies supports the hypothesis that the consumption of n-3 fatty acids (EPA, DHA, α-linolenic acid), fish, and fish oil reduces all-cause mortality and various CVD outcomes. These outcomes include sudden death and cardiac death (coronary or myocardial infarct (MI) death).

The central question is, "How much fish consumption in these studies was necessary to elicit a cardioprotective effect?" Collectively, evidence from five U.S. epidemiologic studies (Albert et al., 1998; Dolocek et al., 1992; Hu et al., 2002; Mozaffarian et al., 2003; Siscovick et al., 2000) found that the average intake of EPA and DHA (estimated from fish consumption) associated with the lowest risk of coronary events (including CHD death, primary cardiac arrest and ischemic heart disease death) was 496 mg per day. The range of EPA and DHA intake in the studies that conferred the lowest risk was 246 mg per day to 919 mg per day. Because these estimates were derived from fish consumption, it is important to put the average of 496 mg per day of EPA and DHA per day in the context of the amount of fish consumed to achieve this level of intake. A daily intake of 496 mg of EPA and DHA is equivalent to about 3.5 g per week. This is approximately equivalent to the amount of EPA and DHA in two 4-oz. servings of high n-3 fish per week, based on an average EPA and DHA content of high n-3 fish of 1.6 g per serving (values derived from USDA database). These data provide the rationale for the recommendation for two servings of high n-3 fish per week.

There is some evidence that consuming more than two servings of fish per week may confer further cardioprotective effects. This was observed in the Mozaffarian et al. (2003) study that found that more than two servings of fish per week (which contributed 919 mg per day of EPA and DHA) was associated with the lowest risk for CHD. In addition, two recent meta-analyses report that fish consumption five or more times per week is associated with lower CHD mortality (He et al., 2004a) and lower incidence of stroke (He et al., 2004b). Compared with those who never consumed fish or ate fish less than once per month, the relative risks for CHD mortality were 0.89 for fish intake 1 to 3 times per month; 0.85 for once per week; 0.77 for 2 to 4 times per week; and 0.62 for 5 or more times per week (He et al., 2004a). The authors reported that for each 20 g per day increase in fish intake there was a corresponding 7 percent lower risk of CHD mortality. Compared with no fish intake or intake less than once per month, the relative risks for total stroke were very slightly higher than those for CHD mortality at each level of fish intake (He et al., 2004b). The relative risks for ischemic stroke were lower than for total stroke: 0.69 for fish intake 1 to 3 times per month; 0.68 for once per week; 0.66 for 2 to 4 times per week; and 0.65 for 5 or more times per week (p for trend = 0.24). Thus, the optimal quantity of fish to consume is not yet clear. Similarly, the AHRQ report (Wang et al., 2004) did not define the optimal quantity of n-3 fatty acids to consume because of the lack of sufficient evidence.

The AHRQ report did conclude, however, that the consumption of n-3 fatty acids from fish or from supplements of fish oil reduces all-cause mortality and various CVD outcomes. The available evidence indicates that the active dietary factor in fish is EPA and DHA. The *DART* study (Burr et al., 1989) showed that male MI survivors who consumed 200 to 400 g of n-3 rich fish per week, which provided an additional 500 to 800 mg per day of n-3 fatty acids to current intake, had the same reduction in recurrent events as did patients receiving fish oil capsules containing 900 mg per day of EPA and DHA. In addition, the *Gruppo Italiano per lo Studio della Sopravvivenza nell'Infarto Miocardico* (GISSI) *Prevention Study* (GISSI-Prevenzione Investigators, 1999), the largest prospective clinical trial to test the efficacy of n-3 fatty acids for secondary prevention of CHD, showed that subjects randomized to the EPA + DHA supplement group (850 mg per day of omega-3 fatty acid ethyl esters with and without 300 mg of vitamin E per day) experienced a 15 percent reduction in the primary endpoint of death, nonfatal MI and nonfatal stroke ($p < 0.02$). In addition, all-cause mortality was reduced by 20 percent ($p = 0.01$) and sudden death was reduced by 45 percent ($p < 0.001$) compared with the control group (vitamin E provided no benefit). Further evidence to support the importance of EPA and DHA comes from the Indian Experiment of Infarct Survival (Singh et al., 1997). MI survivors who were treated with either fish oil capsules (1.8 g per day EPA + DHA) or mustard oil (2.9 g per day α-linolenic acid) for one year had fewer total cardiac events, nonfatal infarctions, arrhythmias and less left ventricular enlargement and angina pectoris than did the placebo group. Only the group treated with fish oil experienced a decrease in cardiac deaths (Singh et al., 1997). Collectively, the available evidence from the controlled clinical trials demonstrates that EPA and DHA are the bioactive compounds that elicit cardioprotective benefits. Thus, these results provide an explanation for the cardioprotective effects of fish consumption reported in the epidemiologic studies.

Although the preponderance of evidence supports a beneficial effect of fish consumption, two studies found no association between fish consumption and health outcomes (Kromhout et al., 1996). Differences in study findings likely relate to differences in the definitions of endpoints and residual confounding of reference groups with less healthy lifestyles (Guallar et al., 1999; Kromhout, 1998); variability in the endpoints studied, the experimental design, the method of estimating fish intake, and differences in the study populations (Sheard, 1998); or a small fraction of the study population reporting little or no fish consumption (Albert et al., 1998).

Fish is a good source of nutrients including protein, the B-vitamins and minerals such as potassium, phosphorous, and selenium and also is low in calories. Since fish is low in saturated fat, it provides a means to reduce saturated fat intake when substituted for foods such as red meats and full-fat dairy products.

Special Analysis

At the Committee's request, USDA's Center for Nutrition Policy and Promotion used a modeling process described in Appendix G-2 to examine how incorporating 8 ounces per week of fish (approximately twice that of current consumption) and/or fish high in n-3 fatty acids in the food intake patterns would affect the nutrient profiles of patterns ranging from 1,000 to 3,200 calories per day. First, all fish items were separated into low n-3 (LO-3) or high n-3 (HI-3) subgroups. The cutoff value specified for placement into the LO-3 or HI-3 group was 500 mg of EPA plus DHA in a 3-ounce serving of the fish. Using this approach, on average, 1 ounce of HI-3 fish (e.g. mackerel, salmon, trout) contains 407 mg of EPA+DHA, and 1 ounce of LO-3 fish (e.g. cod, haddock, snapper) contains 105 mg of EPA+DHA.

Substituting either more fish or HI-3 fish for some meat and poultry in the food intake pattern had little impact on the amounts of other nutrients provided by the food pattern. For most nutrients, no change was evident when expressed as a percentage of the RDA or AI. For iron, a decrease of 2 to 4 percent was seen in the patterns with the 8 ounces of HI-3 fish. For other nutrients, the change was only 0 to 2 percent. The change in total fat was 0 to 1 percent of calories, depending on the calorie level of the pattern.

Using the estimates from USDA's special analysis (see above), 8 ounces of fish that is high in n-3 fatty acids would provide approximately 3,250 mg of EPA+DHA a week—an average of slightly less than 500 mg per day, which is about a two-fold increase over current intake (see below). Adverse effects are not observed until intake exceeds 3 g per day (*Federal Register* notice, 1997).

Positions Taken by Other Expert Groups

The American Heart Association—two servings of fish (preferably fatty) per week
(Krauss et al., 2000; Kris-Etherton et al., 2002).

National Cholesterol Education Program—recommends fish as a food item for people to choose more often
(NCEP, 2002; Table V.2–6).

World Health Organization—regular fish consumption (one to two servings per week; each serving should provide the equivalent of 200 to 500 mg of EPA+DHA)
(WHO, 2003).

European Society for Cardiology—oil fish and n-3 fatty acids have particular protective properties for primary CVD prevention
(De Backer et al 2003; Priori et al. 2003; Van de Werf et al., 2003).

United Kingdom Scientific Advisory Committee on Nutrition—consume at least two portions of fish per week, of which one should be oily, and provide 450 mg per day of EPA+DHA
(Scientific Advisory Committee on Nutrition, 2004).

American Diabetes Association—two to three servings of fish per week provide dietary n-3 polyunsaturated fats and can be recommended
(Franz et al., 2004).

Summary

Collectively, the evidence presented above provided the basis for recommending two servings of fish per week to decrease risk of heart disease. A conservative estimate is that two servings of fish high in n-3 fatty acids per week may reduce the risk of coronary death, primarily sudden death, by as much as 30 percent (Hu et al., 2002) among adults. Fish is recommended rather than supplements because epidemiologic and some RCT data demonstrate benefits of fish; it is a good source of n-3 fatty acids and many other nutrients; and it is low in calories and saturated fatty acids (see Table D4-3, EPA+DHA content of selected fish).

n-3 Fatty Acid Intake

Based on intake data from CSFII (1994–1996, 1998), the total median n-3 fatty acid intake for men and women ranged from 1.3 to 1.8 g per day and 1.0 to 1.2 g per day, respectively (IOM, 2002, Appendix Table E-10).

Depending on age, the median intake of α-linolenic acid ranged from 1.2–1.6 g per day for men and 0.9 to 1.1 g per day for women. Estimated mean intake of α-linolenic acid, based on over 29,000 NHANES III respondents, was 1.33 g per day. This was equivalent to 0.55 percent of total energy intake per day (Wang et al., 2004, Table 3.4).

For all adults, the median intakes of EPA and DHA range from 0.004 to 0.007 g per day and 0.052 to 0.093 g per day, respectively (IOM, 2002, Appendix Tables E-12 and E-14).

Mean intake of EPA and DHA, based on analyses of a single 24-hour recall of NHANES III data, were 0.04 and 0.07 g per day, respectively. Distributions for EPA and DHA were very skewed and data on intakes should be used and interpreted with caution (Wang et al., 2004, Table 1.1).

Based on NHANES 1999–2000 data, mean intake of fish is 2.92 ounces per week (CNPP analysis, Appendix G-2). The majority of the fish consumed (63 percent) is finfish and shellfish that contain less than 500 mg of n-3 fatty acids per 3-ounce serving. The most commonly consumed single fish is tuna (representing 22 percent of total fish consumption), with shrimp (16 percent), salmon (9 percent), mixed fish (8 percent), and crab (7 percent) also commonly reported. Emphasis will need to be placed on fish high in n-3 fatty acids to achieve the recommendation for fish consumption.

Other sources of long chain n-3 fatty acids are currently on the market. Some are fortified with deodorized fish oil or contain algae as the source of EPA + DHA. With the pending availability of agronomic crops such as corn and soybeans that have been genetically enhanced to contain EPA and DHA, it is conceivable that vegetable oils rich in these n-3 fatty acids will become an important plant source of these fatty acids. EPA + DHA supplements may provide variable amounts of these fatty acids (Consumer Reports, 2003). The α-linolenic acid from plant sources including canola and soybean oils, walnuts and flaxseed can be converted to a limited extent (approximately 10 percent) to EPA + DHA in the body.

Supplementary Information

See the section, "Methylmercury in Fish" in Section 9, "Food Safety" for cautions regarding types of fish to avoid or to eat in limited amounts.

Table D4-3. EPA and DHA Content of Selected Types of Fish

Fish and Description	**EPA+DHA** (g) **per 3 oz of fish**
Cod, Atlantic, cooked, dry heat	0.134
Crab, Alaska king, cooked, moist heat	0.351
Flounder, cooked, dry heat	0.426
Haddock, cooked, dry heat	0.202
Mackerel, Pacific and jack, mixed species, cooked, dry heat	1.571
Pollock, Atlantic, cooked, dry heat	0.461
Salmon, Atlantic, farmed, cooked, dry heat	1.825
Shrimp, mixed species, cooked, moist heat	0.268
Snapper, mixed species, cooked, dry heat	0.273
Trout, mixed species, cooked, dry heat	0.796
Tuna, fresh, blue fin, cooked, dry heat	1.278
Tuna, light, canned in water, drained solids	0.230
Tuna, white, canned in water, drained solids	0.733

Note: For information on methylmercury in fish, refer to Section 9, "Food Safety"
Source: USDA, Center for Nutrition Policy and Promotion Analysis (Appendix G-2)

Question 7: What Are Relationships Between MUFA Intake and Health?

Conclusion

There is an inverse relationship between the intake of MUFAs and the total cholesterol (TC):HDL cholesterol (HDL-C) concentration ratio. If equal amounts of MUFAs are substituted for saturated fatty acids, LDL-C decreases.

Rationale

Overview

This conclusion was supported by evidence from the IOM (2002) review of 19 clinical trials; the evidence-based review conducted by the Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (2002); and the Committee's review of 18 more recent controlled trials.

Since humans can synthesize MUFAs from other fats and from carbohydrates, MUFAs are not required in the diet. However, MUFAs are present in virtually all fat-containing foods, and the dietary intake of MUFAs benefits human health by providing a vehicle to achieve total fat recommendations within the context of recommendations for the intakes of saturated fatty acids and PUFAs.

Implicit to a discussion of monounsaturated fats is how the level of MUFA intake affects various biological endpoints relative to intakes of other fatty acid classes. Table D4-4 illustrates some different ways that MUFAs can vary in the diet. In one scenario, MUFAs could be held constant within a constant amount of total fat, and the amount of saturated fatty acids and PUFAs would vary. Alternatively, MUFAs could vary within a constant amount of total fat, while saturated fatty acids and PUFAs vary. Or, MUFAs could be held constant while total fat and other fatty acids vary. Lastly, MUFAs and total fat could vary while saturated fatty acids and PUFAs are held constant. As shown, the MUFA content of the diet, expressed as a percentage of total calories, can vary with the percentage of energy provided by other fatty acids, the percentage of energy provided by total fat, and a combination of the two. The carbohydrate and protein as a percentage of calories can vary as well. The examples shown in the table are only a few of the many possible combinations. Thus, the biological effects of MUFAs must be studied in the context of the level of total fat (and other macronutrients) and the other fatty acid classes.

Table D4-4. Examples of the Many Varying Patterns of Fats, Fatty Acids, and Carbohydrates Possible (Protein level can be determined by difference [total energy percent–(total fat percent + carbohydrate percent) = protein percent])

	Total Fat	SFA	MUFA	PUFA	CHO*
	Percent of Total Energy				
MUFA Constant; Total Fat Constant					
MUFA constant, total fat constant at 35 percent; other fatty acids vary	35	9	20	6	50
	35	5	20	10	50
MUFA constant, total fat constant at 20 percent; other fatty acids vary	20	5	10	5	65
	20	4	10	6	65
MUFA Varies; Total Fat Constant					
Total fat constant at 35 percent, MUFA vary; other fatty acids vary	35	7	23	5	50
	35	8	18	9	50
Total fat constant at 20 percent, MUFA vary; other fatty acids vary	20	7	8	5	65
	20	5	10	5	65
MUFA Constant, Total Fat Varies					
Total fat varies, MUFA constant; other fatty acids vary	33	9	14	10	52
	22	3	14	5	52
MUFA Varies, Total Fat Varies					
Total fat, CHO, & MUFA vary; other fatty acids constant	30	5	18	7	55
	20	5	8	7	65

SFA = saturated fatty acids

MUFA = MUFAs

PUFA = PUFAs

CHO = carbohydrate

*Protein held constant at 15 percent of energy for these calculations. Variations in the percentage of energy from protein would change the percentage of energy from carbohydrates.

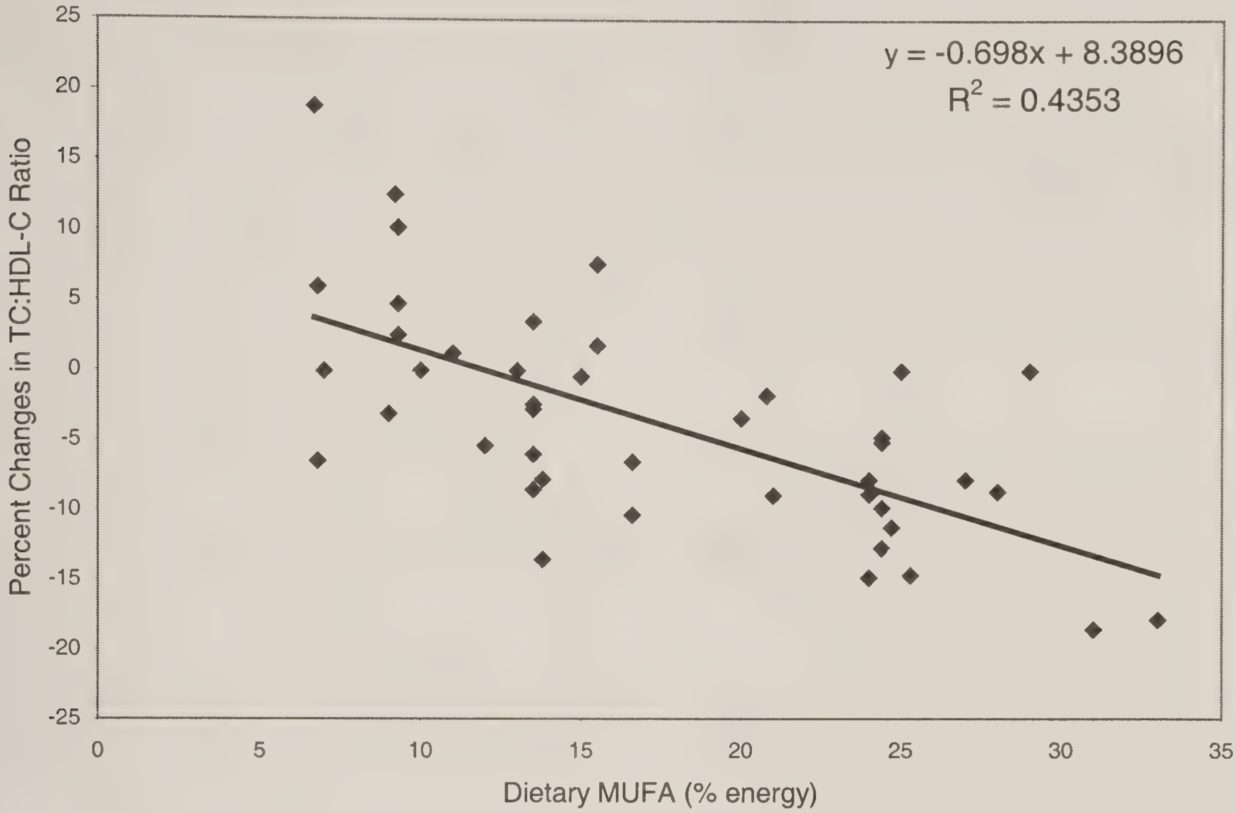
Review of the Evidence

MUFAs and Blood Lipids—Figure D4-5, below, demonstrates that an increase in MUFA intake as a percentage of total energy intake results in a decrease in the total cholesterol:HDL-cholesterol ratio (IOM, 2002). A meta-analysis of feeding studies estimated that the regression coefficients for the effects of MUFAs on LDL and HDL cholesterol concentrations were -0.008 and +0.006, respectively, suggesting a slight positive benefit (Clarke et al., 1997).

MUFAs and the Metabolic Syndrome—Recent publications reported the following effects of MUFAs on components of the metabolic syndrome:

- Ten clinical trials that replaced carbohydrates with MUFAs found that MUFAs may have beneficial effects on some aspects of glycemic control (Brynes et al., 2003; Campbell et al., 1994; Garg et al., 1994, 1992; Heilbronn et al., 1999; Parillo et

Figure D4-5. IOM Figure11-4: Relationship Between Monounsaturated Fatty Acid Intake and Total Cholesterol (TC): HDL Cholesterol (HDL-C) Concentration Ratio



Weighted least-squares regression analyses were performed using the mixed procedure to test for differences in lipid concentrations (SAS Statistical package, version 8.00, SAS Institute, Inc., 1999).

Source: IOM (Institute of Medicine). Dietary Reference Intakes: Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: National Academies Press, 2002.

al., 1992; Rasmussen et al., 1993; Scott et al., 2003; Straznicky et al., 1999; Wien et al., 2003).

- Four clinical trials that replaced saturated fatty acids with MUFAs showed improvement in lipid profiles and some beneficial effects on insulin sensitivity (Heilbronn et al., 1999; Lovejoy et al., 2002; Perez-Jimenez et al., 2001; Vessby et al., 2001).

A summary of the available evidence demonstrates that, compared with a high-carbohydrate diet (greater than 65 percent of calories from carbohydrate), a diet that provides approximately 20 percent of total calories from MUFA and 35 percent from total fat improves glycemic control in individuals with type 2 diabetes mellitus who maintain their body weight. Specifically, such a diet may decrease triglyceride and increase HDL cholesterol concentrations. Individuals with elevated triglycerides or insulin levels may benefit from increasing MUFAs in the diet (by replacing some carbohydrate calories with a comparable number of calories from MUFAs). In addition, Krauss (2001) has shown that a moderate-fat diet that emphasizes MUFAs may decrease the risk of expression of the atherogenic lipoprotein phenotype (characterized by high triglycerides; low HDL cholesterol; high small-dense LDL) (Reaven, 2001). A review of 18 well-controlled clinical studies compared the effects of substituting either MUFAs or carbohydrate for saturated fat in a blood cholesterol-lowering diet (Kris-Etherton et al., 2000). Replacing saturated fatty acids with MUFAs was found to reduce total and LDL cholesterol values. Compared to baseline values, the range of serum total cholesterol concentration change was -17 to +3 percent on the low-fat/high-carbohydrate diet, whereas the range was -20 to -3 percent on the high-MUFA diet. The range of decrease in plasma LDL cholesterol concentration was similar (-22 to +1 percent) among subjects on the two diets. The change in serum triacylglycerol concentrations ranged from -23 to +37 percent for subjects consuming the low-fat/high-

carbohydrate diets and from -43 to +12 percent for diets high in MUFAs. Changes in HDL cholesterol concentrations ranged from -25 to +2 percent for subjects on the low-fat/high-carbohydrate diets compared to a -9 to +6 percent change for subjects on diets high in MUFAs. These data indicate that in weight-stable individuals, a high MUFA-low saturated fatty acid diet results in a more favorable metabolic profile with respect to total cholesterol, HDL cholesterol, and triacylglycerol concentrations than the baseline diet or a low-fat/high-carbohydrate diet. The evidence is clear that replacing saturated fatty acid calories with MUFAs lowers total and LDL cholesterol levels.

Positions Taken by Other Expert Groups—Using an evidence-based approach, the NCEP Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults published the following evidence statement and recommendation related to MUFAs:

> ***Evidence Statement***
> Monounsaturated fatty acids lower LDL cholesterol relative to saturated fatty acids. Monounsaturated fatty acids do not lower HDL cholesterol nor raise triglycerides. Dietary patterns that are rich in monounsaturated fatty acids provided by plant sources and rich in fruits, vegetables, and whole grains and low in saturated fatty acids are associated with decreased CHD risk. However, the benefits of replacement of saturated fatty acids with monounsaturated fatty acids has not been adequately tested in controlled clinical trials.
>
> ***Recommendation***
> Monounsaturated fatty acids are one form of unsaturated fatty acid that can replace saturated fatty acids. Intake of monounsaturated fatty acids can range up to 20 percent of total calories. Most monounsaturated fatty acids should be derived from vegetable sources, including plant oils and nuts.
>
> (National Cholesterol Education Program ATP III Expert Panel, 2002, p. V-10)

In addition, an evidence-based technical report of the American Diabetes Association included the following statements for MUFAs and diabetes:

> For persons with elevated plasma triglycerides, reduced HDL cholesterol, and small-dense LDL cholesterol (the metabolic syndrome), improved glycemic control, modest weight loss, dietary saturated fat restriction, increased physical activity, and incorporation of MUFAs may be beneficial.
>
> Carbohydrate and MUFA together should provide 60 to 70 percent of energy intake. However, the metabolic profile and need for weight loss should be considered when determining the monounsaturated fat content of the diet.
>
> To lower LDL cholesterol, energy derived from saturated fat can be reduced if weight loss is desirable or replaced with either carbohydrate or monounsaturated fat when weight loss is not a goal.
>
> (Franz et al., 2004, p. S39)

MUFA Intake

Based on dietary intake data from CFSII (1994–96), median MUFA intake ranged from 25 to 39 g per day for men and 18 to 24 g per day for women (IOM, 2002, Appendix Table E-8). Data from the 1987–1988 Nationwide Food Consumption Survey indicated that mean intakes of MUFAs for different age-gender groups were 13.6 to 14.3 percent of energy (Ganji and Betts, 1995).

In children and adolescents, MUFA intake ranged from 12.1 percent of energy for males age 2 to 3 years and 4 to 5 years to 12.9 percent of energy for males age 16 to 19 years. Among males age 12 to 19 years, MUFAs accounted for 12.7 percent of calories for non-Hispanic blacks compared with 12.6 percent and 12.8 percent for non-Hispanic whites and Mexican Americans. For females age 12 to 19 years, monounsaturated fatty acid intake was 13.5 percent for non-Hispanic blacks, compared with 12.4 percent for non-Hispanic whites and 12.7 percent for Mexican Americans (Troiano et al., 2000). Thus, the collective evidence from studies that have assessed the diet of persons in the United States indicate that MUFA intake is approximately 12 to 14 percent of calories.

Supplementary Information

Most MUFAs should be derived from plant sources rather than animal sources: plant sources of MUFAs are lower in saturated fatty acids than are animal sources, and plant sources contain no cholesterol. Also, some plant sources of MUFAs provide vitamins and other compounds that may confer health benefits.

Summary

To reduce the risks of elevated serum LDL cholesterol and of CHD, the Committee recommends three measures:

1. Limiting saturated fat intake to less than 10 percent of calories
2. Limiting *trans* fat intake as much as possible
3. Limiting dietary cholesterol intake to less than 300 mg per day

To promote recommended intakes of vitamin E and essential fatty acids and to decrease the risk of adverse changes in certain blood lipids, the Committee recommends a total fat intake of at least 20 percent of calories. To help reduce the risk of obesity and CHD, the Committee recommends keeping total fat intake at or below 35 percent of calories. Current mean intakes of n-6 PUFAs are within the recommended range for essential fatty acid intake and for obtaining beneficial effects on mortality from coronary artery disease. To reduce the risk of sudden death and CHD death, the Committee recommends the consumption of fish twice weekly, especially fish that are good sources of EPA and DHA. Other sources of EPA and DHA may provide similar benefits; however, further research is warranted.

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Section 5: Carbohydrates

Introduction

Carbohydrates—the sugars, starches, and fibers found in fruits, vegetables, grains, and milk products—are an important part of a healthy diet. Sugars and starches supply energy to the body in the form of glucose, which is the primary energy source for the brain, central nervous system, and red blood cells. Fibers, unlike sugars and starches, do not supply glucose to the body. They promote healthy laxation and decrease the risk of certain chronic diseases such as coronary heart disease (CHD) and diabetes.

Nomenclature for Carbohydrates

The nomenclature for carbohydrates is somewhat confusing. Sugars can be one sugar unit (monosaccharides) such as glucose, fructose, and galactose; and they can be two sugar units linked together (disaccharides) such as sucrose, lactose, and maltose. A further distinction is sometimes made between ***intrinsic*** and ***extrinsic*** sugars. The term ***intrinsic sugar*** means those sugars that are naturally occurring within a food, whereas ***extrinsic sugars*** are those that are added to foods. The U.S. Department of Agriculture (USDA) has defined added sugars as sugars and syrups that are added to foods during processing or preparation, and also includes sugars and syrups added at the table. There is no difference in the molecular structure of sugar molecules, whether they are naturally occurring in the food or added to the food.

Starches are many glucose units linked together (polysaccharide). Although most starch can be broken down by human enzymes into glucose for absorption, some starch does not undergo digestion in the small intestine and is called ***resistant starch***, which is found in plant foods such as legumes, pasta, and refrigerated cooked potatoes. Fibers, like starches, are polysaccharides made up mostly of glucose units (in the case of cellulose) or other combinations of monosaccharides. However, the monosaccharides in fibers are bonded to each other differently than they are in starches, and human enzymes cannot break the bonds in the fibers. Thus, fibers are not absorbed from the small intestine and pass relatively intact into the large intestine, as does resistant starch.

Recommendations for the Intake of Sugars and Starches

The Institute of Medicine (IOM) report *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids* (IOM, 2002) established a Recommended Dietary Allowance (RDA) for carbohydrates at 130 g per day for adults and children. This value is based upon the amount of carbohydrates (sugars and starches) required to provide the brain with an adequate supply of glucose. Glucose is the only energy source for red blood cells and the preferred energy source for the brain, central nervous system, placenta, and fetus. When muscle cells operate anaerobically (without oxygen), they rely 100 percent on glucose. If glucose is not provided in the diet and the body's storage form of glucose (glycogen) is depleted, the body will break down protein in muscles to maintain glucose blood levels and supply glucose to the brain (IOM, 2002).

IOM also set an Acceptable Macronutrient Distribution Range (AMDR) for carbohydrate of 45 to 65 percent of total calories. At the low end of this range, it is very difficult to meet the recommendations for fiber intake, and at the high end of the range overconsumption of carbohydrates may result in high blood triglyceride values. A comparison of the RDA with the AMDR shows that the recommended range of carbohydrate intake is higher than the RDA. For example, if an individual with a caloric intake of 2,000 calories per day were to consume 55 percent of calories as carbohydrate (the mid-range of the AMDR) that would mean that 1,100 calories would be from carbohydrate. This equates to 275 g carbohydrate (1 g carbohydrate = 4 calories), well above the RDA of 130 g per day. In summary, the primary beneficial physiological effect of sugars and starches, and the basis for setting an RDA for carbohydrate, is the contribution of glucose as an energy source for the brain. However, the amount of glucose needed by the brain is lower than the AMDR for carbohydrate (45 to 65 percent of total calories).

Recommendations for the Intake of Fiber

Fibers are different from sugars and starches in that they are not digested and absorbed in the small intestine and converted to glucose. Humans do not have the necessary enzymes to break down fibers into their constituent parts so that they can be absorbed into the body. Therefore, fibers pass from the small intestine into the large intestine relatively intact. There they can be fermented by the colonic microflora to gases such as hydrogen (H_2) and carbon dioxide (CO_2) and to short chain fatty acids. Although fibers are not converted to glucose as are sugars and starches, some of these short chain fatty acids are absorbed and can be used for energy in the body. However, determining the amount of calories supplied by fiber is complex since it depends on such factors as the fermentability of the fiber, the individual's colonic microflora, how long fiber stays in the colon, etc. The IOM has set an Adequate Intake (AI) value for fiber of 14g of fiber per 1,000 calories. This AI is based on the totality of the evidence for fiber decreasing the risk of chronic disease and other health-related conditions, but the actual numbers for the AI were derived from the data supporting a decreased risk for the development of CHD. The major food sources of fiber are fruits, vegetables (particularly legumes), and grains. Milk does not contain fiber, although certain milk-containing products may.

Major Food Sources of Carbohydrates (Fruits, Vegetables, Grains, and Milk Products)

Since the RDA for carbohydrate is relatively easy to meet, and carbohydrates (sugars and starches) supply calories, it is important to choose food sources of carbohydrates carefully to maximize nutrient value per calorie. Also, since fiber has known health benefits (e.g., promoting a healthy laxation and decreasing the risk of CHD and diabetes), it is advisable to select high-fiber foods where possible. For example, fruits provide sugars, usually at a relatively low calorie cost, and they are important sources of fiber and at least eight additional nutrients. Some vegetables are high in starch and some are very low in both starch and sugar, but they all are important sources of fiber. They also are important sources of 19 or more nutrients, including vitamins A and E, folate, and potassium, and, in general, do not supply many calories. Whole grains are high in fiber and starch, but most of the fiber is removed when grains are refined. Milk and milk products contain the sugar lactose and generally do not contain any fiber but may in certain milk products.

Overview of Questions Addressed

Five of the questions about carbohydrates and carbohydrate-rich foods are specific to carbohydrates and are found in this section. Other questions that also involve carbohydrate-related issues are found elsewhere in this report but are summarized here to provide a better overview of the role of carbohydrates in health.

The following questions specific to carbohydrates are found in this section:

1. What is the relationship between intake of carbohydrates and dental caries?
2. What is the relationship between carbohydrate intake and incidence of diabetes mellitus?
3. What is the utility of the glycemic index/glycemic load for providing dietary guidance for Americans?
4. What is the significance of added sugars intake to human health?
5. What are the major health benefits of fiber-containing foods?

In the interest of presenting a more comprehensive section on carbohydrates, below is a list of related questions, the section of the report in which they are found, and conclusions in brief.

6. What are the major health benefits of carbohydrate-containing foods?

This information is found in Part D, Section 6, "Selected Food Groups (Fruits and Vegetables, Whole Grains, and Milk Products)." The conclusions are:

- Greater consumption of fruits and vegetables is associated with a reduced risk of stroke and perhaps other cardiovascular diseases, with a reduced risk of cancers in certain sites, and with a reduced risk of type 2 diabetes (vegetables more than fruit). Moreover, increased consumption of fruits and vegetables may be a useful component of programs designed to achieve and sustain weight loss.
- Consuming at least three servings of whole grains per day can reduce the risk of diabetes and CHD and may help with weight maintenance. Thus, daily intake of three or more servings of whole grains per day is

recommended, preferably by substituting whole grains for refined grains.

- Consuming three servings per day of milk and milk products can reduce the risk of low bone mass and contribute important amounts of many nutrients. Furthermore, this amount of milk product consumption is not associated with increased body weight. Therefore, the intake of three servings of milk products per day is recommended.

7. What are the optimal proportions of dietary fat and carbohydrate to maintain body mass index (BMI) and to achieve long-term weight loss?

This information is found in Section 2, " Energy," Question #3. The conclusion is that weight maintenance depends on a balance of energy intake and energy expenditure, regardless of the proportions of fat, carbohydrate, and protein in the diet. For adults, well-planned weight loss diets that are consistent with the AMDRs for fat, carbohydrate, and protein can be safe and efficacious over the long term.

8. What is the evidence to support caloric compensation for liquid versus solid foods?

This discussion and review of the literature is found in Section 2, "Energy, Unresolved Issues." The conclusion is that the evidence is conflicting that liquid and solid foods differ in their effect on calorie compensation (the ability to regulate energy intake with minimal conscious effort, such as reducing the amount of food consumed on some occasions to compensate for increased consumption at other times).

Question 1: What Is the Relationship Between Intake of Carbohydrates and Dental Caries?

Conclusion

The intake of carbohydrates (including sucrose, glucose, fructose, lactose, and starch) contributes to dental caries by providing substrate for bacterial fermentation in the mouth. Drinking fluoridated water and/or using fluoride-containing dental hygiene products help reduce the risk of dental caries. A combined approach of reducing the frequency and duration of exposure to fermentable carbohydrate intake and optimizing oral hygiene practices is the most effective way to reduce caries incidence.

Rationale

Overview

The process of dental caries formation involves three steps: the fermentation of substrate by cariogenic bacteria in the mouth to produce acid, demineralization of the enamel surface by the acid, and subsequent bacterial invasion. Factors that affect this process include the type and amount of substrate, the bacterial population, the length of time the substrate is available to the bacteria, and the susceptibility of the tooth to acid demineralization.

Review of the Evidence

The Substrate for Bacterial Fermentation—The major substrates for bacterial fermentation are sugars (including sucrose, glucose, fructose, and lactose) and starch (Bibby, 1975; Lingstrom et al., 2000; Moynihan and Petersen, 2004; Walker and Cleaton-Jones, 1992). In contrast, certain dietary fibers (e.g., cellulose and pectin) (Touger-Decker and van Loveren, 2002) and dietary sugar alcohols and certain other sugar substitutes (e.g., xylitol, sorbitol, mannitol, maltitol, isomalt, lactitol, hydrogenated starch hydrolysates, hydrogenated glucose syrups, erythritol, or a combination of these) are much less cariogenic than other carbohydrates (FDA, 1997, 2002; Makinen et al., 1995). However, evidence as to whether or not substituting sucrose with sugar substitutes to reduce caries occurrence is effective remains inconclusive (Lingstrom et al., 2003).

Other Factors That Affect Caries Formation—Despite the known ability of both sugar and starch to be fermented to acids that can induce demineralization of enamel, their overall contribution to caries formation is less clear and not a simple cause-and-effect relationship (Walker and Cleaton-Jones, 1992). Other important considerations are the form of the food, how long it remains in the mouth, and the frequency of consumption. The longer a cariogenic substance remains in the oral cavity, the greater the probability of extended acid production and demineralization (Kashket et al., 1996). The duration of acid production also is affected by the frequency and amount of fermentable carbohydrate consumed (Lingstrom et al., 2000). Sugars that are slowly released (e.g., from hard candies) or sweetened beverages that are sipped over time or held in the mouth provide greater access to bacteria than the same amount of sugar in foods or beverages that are swallowed quickly. Other important factors for clearing fermentable substrate from the oral cavity include the activity of salivary enzymes and saliva flow. Clearance of high-starch foods such as cookies and potato chips has been found by some to be

slower than clearance of high-sugar, low-starch foods such as caramels and jelly beans (Edgar et al., 1975; Kashket et al., 1996; Luke et al., 1999).

Dental hygiene may have a greater role in the development of dental caries than does the type of carbohydrate and its retention time in the mouth. For example, in a systematic review of the literature from 1980 to 2000 addressing the question of whether individuals with a high level of sugar intake experience greater caries severity relative to those with a lower level of intake, the authors report that only 2 papers found a strong relationship between sugar consumption and caries development, 16 found a moderate relationship, and 18 found a weak-to-no relationship (Burt and Pai, 2001). A separate study investigated the relative importance of dietary sugars, toothbrushing frequency, and social class as predictors of caries among 1,450 British preschool children. The strength of the association between social class and caries was twice that between toothbrushing and caries, and approximately three times that between sugar confectionery and caries (no other diet component was statistically significant) (Gibson and Williams, 1999). The relationship between sugar confectionery and caries was significant only in those children who brushed less than twice a day (Gibson and Williams, 1999). The authors concluded that regular brushing with a fluoride toothpaste may have greater impact on caries in young children than does restricting sugary foods (Gibson and Williams, 1999).

Heller et al. (2001) came to the same conclusion in their report on the association between sugared soda consumption and caries. Using the dietary and dental examination data from the Third National Health and Nutrition Study (NHANES III), they found no relationship between soft drink consumption and caries in individuals under age 25 but did find a positive association in people over age 25 (Heller et al., 2001). They attributed the lack of association in the younger age group to increased use of fluorides since the 1960s. They attributed the significant association in the older group to the cumulative effects of long-term soft drink consumption. In the development of dental caries, the role of sugar and other carbohydrates is not independent of factors such as fluoridation and oral hygiene (Holbrook et al., 1995; Mascarenhas, 1998; McDonagh et al., 2000; Navia, 1994; Shaw, 1987; Touger-Decker and van Loveren, 2002). Caries have declined in areas where the water has been fluoridated (McDonagh et al., 2000).

The impact of sugar intake on dental caries was reviewed by IOM to determine whether the science supported an upper level (UL) of intake for sugar based on its contribution to tooth decay (IOM, 2002). The report concludes, "Because of the various factors that can contribute to dental caries, it is not possible to determine an intake level of sugar at which increased risk of dental caries can occur" (IOM, 2002). Studies published since those cited in the IOM report and reviewed by the Dietary Guidelines Advisory Committee (the Committee), including a systematic review (Burt and Pai, 2001), support the IOM's conclusion (Anusavice, 2002; Campaign, 2003; Heller et al., 2001; Touger-Decker and van Loveren, 2002).

Young Children

Most of the studies of preschool children report a positive association between sucrose consumption and dental caries (Paunio et al., 1993; Wendt and Birkhed, 1995). Here again, however, other factors (particularly frequent brushing with fluoridated toothpaste) are more predictive of caries outcome than is sugar consumption (Gibson and Williams, 1999; Grindefjord et al., 1996; Paunio et al., 1993; Stecksen-Blicks and Holm, 1995; Wendt et al., 1996). Some studies report increased risk with sugar-sweetened beverages (Wendt et al., 1996), others with candy consumption (Grindefjord et al., 1996), others with a variety of sugar-containing products (Paunio et al., 1993), and still others report that intake of certain sucrose-containing products may be predictive of caries in children with poor dental hygiene (e.g., brushing once a day or less) but not in children with better dental hygiene (Gibson and Williams, 1999). In a longitudinal study tracking caries and diet in children just prior to and after starting school, increased consumption of sugar-containing foods was associated with increased caries in 5-year-olds (Holbrook et al., 1995). In Finland, Ruottinen et al. (2004) followed two groups of boys (one in the highest 5 percentiles and the other in the lowest 5 percentiles for sucrose intake; n= > 66,000 boys) from infancy to age 10 years. They found that children with the highest sucrose intake had a higher score for dental caries than those in the low-sucrose intake group (Routtinen et al., 2004).

Possible Confounding Factors

Interpretation of the cross-sectional studies showing a relationship between sugar intake and dental caries needs to consider the possibility that frequent use of candy, sodas, and other sugar-containing foods may be a proxy for a less than optimal healthy lifestyle, rather than a direct effect of the sugar itself. In addition, a large proportion of the studies on children and dental caries have been conducted outside the United States, making extrapolation to the U.S. population somewhat difficult. Not only are eating

habits different in other countries, but the degree of fluoride availability is different. Nevertheless, there is little doubt that the primary initiating event in caries formation is the fermentation of carbohydrates, particularly sugars and starch.

Question 2: What Is the Relationship Between Carbohydrate Intake and Incidence of Diabetes Mellitus?

Conclusion

A potential health concern for foods that raise blood glucose levels and initiate an insulin response is that they may eventually lead to diabetes. Current evidence suggests that there is no relationship between total carbohydrate intake (minus fiber) and the incidence of either type 1 or type 2 diabetes. The intake of fiber-containing foods is associated with a decreased risk of type 2 diabetes in a number of epidemiological studies.

Rationale

Overview

The ***glycemic response*** is defined as the effects that carbohydrate-containing foods have on blood glucose concentration during the time course of digestion. A number of factors influence the glycemic response to food, including the amount of carbohydrate (Gannon et al., 1998), the type of sugar (glucose, fructose, sucrose, lactose) (Wolever et al., 1994), the nature of the starch (amylose, amylopectin, resistant starch) (O'Dea et al., 1981), cooking and food processing (degree of starch gelatinization, particle size, cellular form) (Snow and O'Dea, 1981), food structure (Jarvi et al., 1995), and other food components (fat and natural substances that slow digestion—lectins, phytates, tannins, and starch-protein and starch-lipid combinations) (Hughes et al., 1989). Other factors affecting the glycemic response to food include fasting and preprandial glucose concentrations (Nielsen and Nielsen, 1989; Rasmussen and Hermansen, 1991; Fraser et al., 1990; Schvarcz et al., 1993), the severity of glucose intolerance (Parillo et al., 1996), and the second meal or *lente* effect (Jenkins et al., 1982). A major concern with increasing postprandial glucose and insulin levels is that there may eventually be a diminished insulin response that could lead to diabetes.

Type 1 diabetes is an immunologic disease in which the beta cells of the pancreas are destroyed by autoimmune processes. Although a number of food-based substances have been invoked as important in the process, there is no clear evidence for any of them. ***Type 2 diabetes*** is a disease that is manifested by insulin resistance and a gradual deterioration of B-cell function. Any dietary insult that abets either of these processes could play a role in its etiology. Does carbohydrate intake predispose to type 2 diabetes? Evidence from four prospective observational studies indicates that it does not (Lundgren et al., 1989; Marshall et al., 1991; Salmeron et al., 1997a, 1997b). In these four studies, there was no association between an increased amount of total carbohydrate in the diet and the development of diabetes mellitus in the cohorts studied over periods as long as 16 years. Also, in an analysis of cross-sectional data from NHANES III, Yang et al. (2003) found no association between carbohydrate intake and HgbA1c (the amount of glycosylated hemoglobin in blood that provides an estimate of how well diabetes is being managed over time), plasma glucose, or serum insulin concentrations. In fact, there was an association between lower total carbohydrate intake and an elevation of serum C-peptide concentration, suggesting a possible association between low-carbohydrate diets and increased basal insulin secretion.

Furthermore, there is no evidence that total sugar intake is associated with the development of type 2 diabetes (Colditz et al., 1992; Janket et al., 2003). These two prospective longitudinal studies show no relationship between the total intake of sugar and the development of type 2 diabetes mellitus. One study actually shows a negative association between sugar intake and diabetes risk (Meyer et al., 2000). Clinical trials show that total dietary sugar does not increase plasma glucose concentrations to a greater extent than do isoenergetic amounts of dietary starch (Mann et al., 2002). However, further analysis within the *Nurses' Health Study* indicates that there may be an association between consumption of sugar-sweetened beverages, other than fruit juices, and an increased risk of type 2 diabetes in women, possibly by providing excessive calories and large amounts of rapidly absorbable sugars (Schulze et al., 2004).

In contrast, intake of fiber has been inversely associated with type 2 diabetes in a number of epidemiological studies (Hu et al., 2001; Meyer et al., 2000; Montonen et al., 2003; Salmeron et al., 1997a, 1997b). For example, in the *Nurses' Health Study*, Salmeron et al. (1997a) reported on fiber intake and its relationship to diabetes. There was a 28 percent risk reduction from the highest to the lowest quintile of fiber intake. However, the source of fiber appears to be important, as cereal fiber but not fruit or vegetable fiber

intake has been inversely associated with risk for diabetes in several studies (Salmeron et al., 1997b). In the *Health Professionals Follow-up Study* (Hu et al., 2001), the risk of developing diabetes did not decrease with higher total fiber intakes, but a risk reduction of 30 percent was observed in the highest quintile of cereal-fiber intake (median 10.2 g per day) compared with the lowest quintile (median intake 1.14 g per day). Again, as in the *Nurses'* cohort, cereal fiber but not fruit or vegetable fiber intake was associated with the protective effect. Similarly, in the *Finnish Mobile Clinic Survey* (Montonen et al., 2003), cereal fiber intake also was associated with a reduced risk of type 2 diabetes. The relative risk between the extreme quartiles of cereal fiber intake was 0.39; $p = 0.01$.

Question 3: What Is the Utility of the Glycemic Index/Glycemic Load for Providing Dietary Guidance for Americans?

Conclusion

Current evidence suggests that the glycemic index and/or glycemic load are of little utility for providing dietary guidance for Americans.

Rationale

Overview

The ***glycemic index*** is a classification proposed to quantify the relative blood glucose response to consuming carbohydrate-containing foods. Operationally, it is the area under the curve for the increase in blood glucose after the ingestion of a set amount of carbohydrate in a food (e.g., 50 g) during the 2-hour postprandial period, relative to the same amount of carbohydrate from a reference food (white bread or glucose) tested in the same individual under the same conditions and using the initial blood glucose concentration as a baseline.

The ***glycemic load*** is an indicator of the glucose response or insulin demand that is induced by total carbohydrate intake. It is calculated by multiplying the weighted mean of the dietary glycemic index of the diet of an individual by the percentage of total energy from carbohydrate.

The ***glycemic response*** is defined as the effects that carbohydrate-containing foods have on blood glucose concentration during the time course of digestion.

Review of the Evidence

Glycemic Index

Although the use of food with a low glycemic index may reduce postprandial glucose, there is not sufficient evidence of long-term benefit to recommend general use of diets that have a low glycemic index.

Glycemic Load

The glycemic load has been used primarily in observational epidemiological studies to examine the effect of diet on the risk of developing chronic diseases such as diabetes, heart disease, and cancer (IOM, 2002). The glycemic load has been reported to be positively associated with the risk of developing type 2 diabetes in men and women (Salmeron et al., 1997a, 1997b). In a cross-sectional study of healthy postmenopausal women, dietary glycemic load was inversely related to plasma high-density lipoprotein (HDL) cholesterol and positively related to fasting triglycerides (Liu et al., 2001). In the analysis of the NHANES III results, a high glycemic load was associated with a lower concentration of plasma HDL cholesterol (Ford and Liu, 2001).

The findings from epidemiological studies indicate a possible relationship between the propensity of diets with a high glycemic load to raise blood glucose levels and increase the risk of type 2 diabetes. To determine the utility of glycemic load in predicting risk, long-term trials are needed in which diets with high glycemic load are compared with low glycemic load diets with regard to outcomes. Also, it is necessary to examine the effect of glycemic load of a mixed meal diet on postprandial glucose and insulin levels. A 4-week study by Wolever and Mehling (2003) comparing high and low glycemic index diets in impaired glucose tolerance subjects showed the high glycemic index diet to have no significant change in glucose, but a lower insulin level than the low glycemic diet.

Relationship of Glycemic Index and Load

The relationship of glycemic index and load has been examined in long-term prospective studies. These have shown inconsistent results. A follow-up study within the *Nurses' Health Study* confirmed the association between glycemic load and risk of type 2 diabetes. However, the *Iowa Women's Health Study* showed no significant relationship between glycemic index or load and the development of diabetes (Meyer et al., 2000).

The inconsistencies among studies are likely due to the poor tools available to measure these dietary components. Food frequency questionnaires can be extremely inaccurate, even in the best of hands. In

addition, the food frequency questionnaires used in these studies were not designed to measure glycemic index or load. The validation data are weak. Prospective, randomized studies are needed to answer this question. The relationship between glycemic index and glycemic load and the development of type 2 diabetes is unclear at this time.

Question 4: What Is the Significance of Added Sugars Intake to Human Health?

Conclusion

Compared with individuals who consume small amounts of foods and beverages that are high in added sugars, those who consume large amounts tend to consume more calories but smaller amounts of micronutrients. Although more research is needed, available prospective studies suggest a positive association between the consumption of sugar-sweetened beverages and weight gain. A reduced intake of added sugars (especially sugar-sweetened beverages) can lower calorie intake, and may be helpful in achieving recommended intakes of nutrients and in weight control.

Rationale

Overview

Added sugars— are sugars and syrups that are added to foods during processing or preparation or at the table. Major sources of added sugars include soft drinks, cakes, cookies, pies, fruitades, fruit punch, dairy desserts, and candy (USDA/DHHS, 2000). Specifically, added sugars include white sugar, brown sugar, raw sugar, corn syrup, corn-syrup solids, high-fructose corn syrup, malt syrup, maple syrup, pancake syrup, fructose sweetener, liquid fructose, fruit-juice concentrate, honey, molasses, anhydrous dextrose, and crystal dextrose. In 1994–1996 USDA food consumption survey data, nondiet soft drinks were the leading source of added sugars in Americans' diets, accounting for one-third of the intake of added sugars (Guthrie and Morton, 2000). Soft drinks were followed by sugars and sweets (16 percent), sweetened grains such as cakes and cookies (13 percent), fruitades/drinks (10 percent), breakfast cereals and other grains such as breakfast bars (10 percent), and sweetened dairy (9 percent). Together, these foods and beverages accounted for 90 percent of Americans' intake of added sugars.

Solid foods with added sugars have a high energy density, while beverages that contain added sugars often are relatively low in energy density because of their high water content. The addition of sugar to a food (e.g., adding sugar to grapefruit or coffee) increases the energy density of the food or beverage as consumed. The issue with added sugars is not that sugars themselves are detrimental to health. Rather, as sugars are added to the diet they provide calories only. Thus, at some amount of additional added sugars, either one compensates by decreasing intake of more nutrient-dense foods, and/or one adds sugars on top of an existing diet and increases caloric intake. Increased calorie intake, in turn, may result in weight gain.

Does Intake of Added Sugars Contribute to Excess Intake of Energy?

The analysis of dietary data on added sugars may underestimate intake because of the underreporting of food intake, which is more pervasive among obese adolescents and adults than among their lean counterparts (Johnson, 2000). It appears that foods high in added sugars are selectively underreported (Krebs-Smith et al., 2000).

Cross-Sectional Studies—Despite these research challenges, most cross-sectional studies have found that an increased intake of added sugars is associated with increased total energy intakes (Bowman, 1999; Gibson, 1996; Lewis et al., 1992; Overby et al., 2004; Storey et al., 2003). An analysis performed by the USDA Center for Nutrition Policy and Promotion (Britten et al., 2000), using the 1994–1996 *Continuing Survey of Food Intakes by Individuals* (CSFII), divided the data set into four groups of equal number according to intake of added sugars expressed in teaspoons. About 59 percent of the group with the highest intake of added sugars consumed more than their 1989 Recommended Energy Allowance, in contrast with only 22 percent of all others (median added sugars consumption for the highest quartile was the equivalent of 36.7 teaspoons).

Teens who reported consuming 26 or more ounces of soft drinks per day consumed a mean of 2,604 kcal per day in contrast to nonconsumers of soft drinks, who consumed 1,984 kcal per day (Harnack et al., 1999). Using NHANES III data, Troiano and colleagues (2000) found that soft drinks contributed a higher proportion of daily energy intake for overweight than for non-overweight children and adolescents. However, a large number of cross-sectional studies show an inverse correlation between the consumption of added sugars and either body weight or BMI (Bolton-Smith and Woodward, 1994; Gibson, 1996; Lewis, 1992). Not all studies, however, adequately adjust for physical activity

levels of the study subjects, suggesting that active people can consume added sugars without gaining weight.

Prospective Studies—The study by Newby et al. (2004) compared changes in BMI over 8 months in 1,345 children age 2 to 5 with their sweetened drink intake. While no correlation was found, the very low level of soda intake (~1 oz per day) weakens the generalizability of this finding. It should be pointed out that the study did not find correlations between BMI and drinks consumed in larger quantities, like milk (20 oz per day) or fruit juice (10 oz per day).

Other recent prospective studies, however, found a weak association between the consumption of sugar-sweetened beverages and weight gain. An observational study by Ludwig et al. (2001) reported a positive association between energy intake and the change in consumption of sugar-sweetened beverages in a group of 548 ethnically diverse schoolchildren followed for 19 months. After adjustments for physical activity and other variables, the increased consumption of sugar-sweetened beverages was a factor independently associated with a minor but statistically significant increase in absolute BMI values in children. Additionally, the change in consumption of diet soda intake was negatively associated with the incidence of obesity, which was defined on the basis of both BMI and triceps-skinfold thickness greater than or equal to the 85th percentile of age- and sex-specific reference data.

Berkey et al. (2004), in a large two-year prospective cohort study of boys and girls age 9 to 14, found that the consumption of sugar-added beverages was associated with small BMI gains. They concluded that the consumption of sugar-added beverages may contribute to weight gain among adolescents, probably because of their contribution to total energy intake.

In a short-term longitudinal study of 30 children, Mrdjenovic and Levitsky (2003) reported that excessive sweetened drink consumption (>12 oz per day) resulted in a reduction in milk intake and an increase in daily energy intakes. Also, these investigators found that the greater the sweetened-drink consumption, the greater the weight gain.

A study of women in the *Nurses' Health Study* examined the association between the consumption of sugar-sweetened beverages and weight change (Schulze et al., 2004). Those with a stable consumption pattern of sugar-sweetened beverages (whether high or low) did not show a difference in weight gain. However, those who increased their sugar-sweetened soft drink consumption from low (<1 per week) to high (>1 per day) had the highest weight gain (4.69 kg in 4 years [1991–1995] and 4.20 kg for 1995–1999). Those who decreased their intake of sugar-sweetened soft drinks had the smallest weight gain (1.34 kg for 1991–1995 and 0.15 kg for 1995–1999).

Another study, however, provided mixed results. Phillips et al. (2004) followed 196 nonobese girls and found no relationship between total energy-dense food consumption and either BMI or the percentage of body fat. The energy-dense foods included baked goods, ice cream, chips, sugar-sweetened soft drinks, and candy. Sugar-sweetened soft drinks were the only food that was significantly related to BMI z-score[1] over the study period, but it was not related to the percentage of body fat.

Intervention Studies—A study by James et al. (2004) is one of the few intervention trials published so far in which a decreased intake of carbonated beverages was a specific target. The goal of the intervention was to prevent excessive weight gain. The study, which included British schoolchildren age 7 to 11, randomized classrooms within each of six schools rather than randomizing individuals. In this cluster scheme, the consumption of carbonated drinks over 12 months decreased modestly by 0.6 glasses per day in the intervention group and increased by 0.2 glasses in the control group but had no effect on BMI or on z-score. The number of clusters with mean BMI above the 91st percentile increased by one in controls (7.5 percent) and did not change in the intervention group. Water intake increased in both groups, but there was no difference in water intake between intervention and control clusters. The findings may have been affected by the study design in that it allowed for intervention and control classrooms to coexist in the same school, a likely source of contamination.

Mattes (1996) suggests that the form in which carbohydrates are consumed (solid or liquid) may be important since, at subsequent meals, people tend to compensate less for energy consumed in liquids than in solids; but this is controversial (see Section 2, "What Is the Evidence To Support Caloric Compensation for Liquids Versus Solid Foods?"). Rolls and colleagues (2002) found, however, that meals including sugar-sweetened beverages are higher in energy content than

[1] The z-score, which represents the number of standard deviations away from the population mean in a normal distribution, indicates the degree to which an individual's measurement deviates from what is expected for that individual.

meals without drinks by an amount roughly equal to the calorie content of the beverage.

In summary, although the evidence is not large and there are methodological problems with this research, the preponderance of prospective data available suggests that added sugars (particularly in beverages) are associated with an increase in energy intake. As a result, decreasing the intake of added sugars (particularly in beverages) may help prevent weight gain and may aid in weight loss.

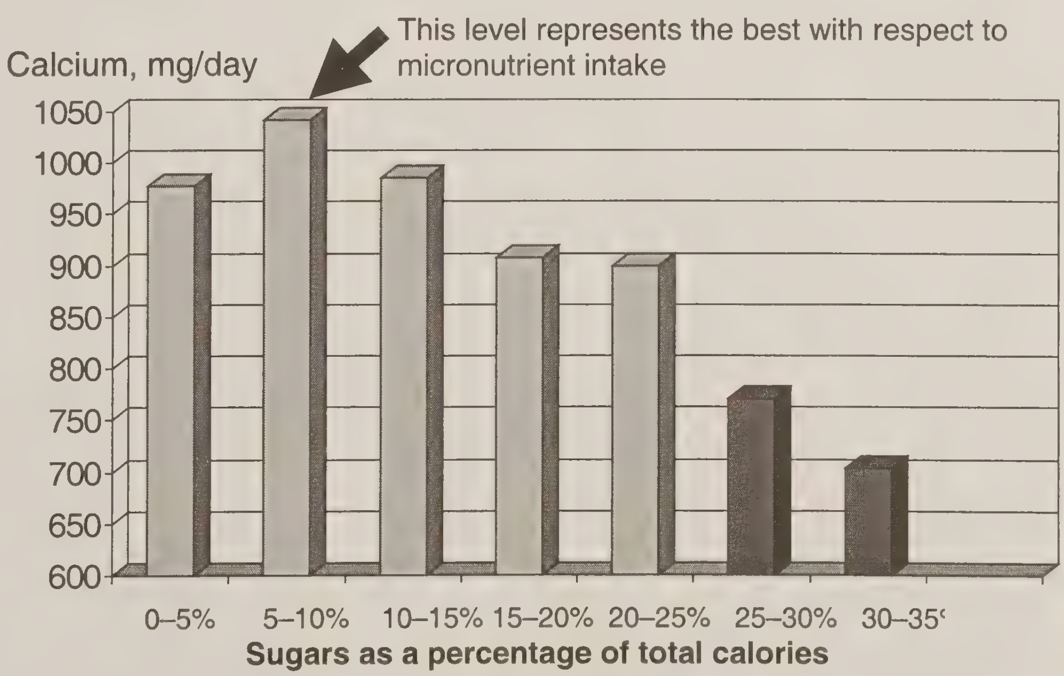
Does Intake of Added Sugars Have a Negative Impact on Achieving Recommended Nutrient Intakes?

The Committee reviewed 19 published papers on the intake of added sugars and corresponding micronutrient intake; 9 were used to develop this rationale. Each of these papers (see Appendix G3 or Web site *www.health.gov/dietaryguidelines*) shows a decreased intake of at least one micronutrient with higher levels of added sugar intake (Bolton-Smith and Woodward, 1995; Bowman, 1999; Forshee and Storey, 2001; Gibson, 1997; Lewis et al., 1992; Nelson, 1991; Nicklas et al., 2003; Rugg-Gunn et al., 1991). For example, the Bowman study (Bowman, 1999) used data from CSFII (1994–1996) (n=14,707) and divided the intake data into three groups: (1) less than 10 percent of total energy from added sugars (n = 5,058); (2) 10 to 18 percent of total energy (n = 4,488); (3) greater than 19 percent of total energy (n = 5,158) (mean = 26.7 percent). Group 3 had the lowest mean intakes of all the micronutrients, especially vitamin A, vitamin C, vitamin B12, folate, calcium, phosphorus, magnesium, and iron. The individuals in Group 3 did not meet the 1989 RDA for vitamin E, vitamin B6, calcium, magnesium, and zinc. In terms of food groups, Group 3 consumed more soft drinks, fruit drinks, punches, ades, cakes, cookies, grain-based pastries, milk, desserts, and candies. They had lower intakes of grains, fruits, vegetables, meat, poultry, and fish compared with those in Groups 1 and 2.

In addition, an IOM panel developed tables to address the association between added sugars and specific micronutrient intakes at every fifth percentile of added sugar intake using data from NHANES III, 1988–1994 (IOM, 2002, Appendix J). Taken collectively, these data show a drop off in micronutrient intake at approximately 25 percent of calories coming from added sugars. The specific drop-off point depends upon the specific micronutrient and the age/sex of the group. Therefore, the IOM recommendation to keep added sugars intake below 25 percent of calories was based solely on the data of added sugar intake and micronutrient dilution—not on whether the people consuming added sugars were, for example, consuming more calories than required to meet their energy needs.

As noted previously, concern about added sugars arises when nutrient-poor foods are consumed at the expense of nutrient-dense foods. Not all foods that contain added sugars are poor sources of nutrients. Sugars can improve the palatability of foods and beverages that otherwise might not be consumed (FAO/WHO, 1998). Interestingly, a review of Appendix Table 1–9 in Appendix J of *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids* (IOM, 2002) shows that individuals consuming 5 to 10 percent of their calories as added sugars have higher micronutrient intakes than those consuming 0 to 5 percent of their calories as added sugars. Figure D5-1 illustrates this point.

Figure D5-1. Calcium intake in 4- to 8-year-old children as a function of added sugar intake



Source: IOM, 2002

A possible reason for this apparent beneficial effect of small amounts of added sugars is from a recent paper (Frary et al., 2004). These investigators conclude that, on average, the consumption of sweetened dairy foods and beverages and presweetened cereals had a positive impact on children and adolescents' diet quality, whereas sugar-sweetened beverages, sugars and sweets, and sweetened grains had a negative impact on their diet quality. The potential negative effects of added sugars appear to be excess calories or micronutrient dilution rather than a direct negative effect of sugar itself.

Added Sugar Intake and Discretionary Calories— Section 3 has a full discussion of the concept of discretionary calories. Added sugars fit into the category of discretionary calories because they are part of the difference between a person's energy requirement and his or her *essential calories*. As shown in Figures D3-1, D3-2a, and D3-2b in that section, individuals may have very few discretionary calories, particularly persons who are sedentary.

Question 5: What Are the Major Health Benefits of Fiber-Containing Foods?

Conclusion

Diets rich in dietary fiber have a number of important health benefits including helping to promote healthy laxation, reducing the risk of type 2 diabetes, decreasing the risk of CHD, and maintaining a healthy body weight. Prospective cohort studies show that decreased risk of heart disease is associated with the intake of 14 g of dietary fiber per 1,000 calories.

Rationale

Overview

The conclusion regarding the recommended intake of dietary fiber is consistent with the IOM's AI value of 14 g of fiber per 1,000 kcals (IOM, 2002). This AI for fiber intake was based on the totality of the evidence for certain health benefits of dietary fiber, placing emphasis on fiber's protective role against CHD but also including its effect on laxation (Burkitt et al., 1972; Cummings, 1992; Kelsay et al., 1978) and diabetes (Colditz et al., 1992; Salmeron et al., 1997a). The Committee evaluated the potential effects of fiber on laxation and diabetes and focused on the effects of fiber on CHD, since that was the basis of setting a value for fiber intake. Particular attention was paid to studies published since the IOM report. Studies on the association between fiber and diabetes are discussed under Question 2 in this section: How important is the glycemic response to carbohydrates to human health? Summaries of the studies on the relationship of fiber to healthy laxation and to risk of CHD are shown below.

Review of the Evidence

Fiber and Laxation—Chronic constipation is one of the most common disorders in Western countries (Roma et al., 1999). Although there is no one accepted definition of what constitutes normal laxation, ***constipation*** has been defined as difficulty in passing stools or an incomplete or infrequent passage of hard stools (Anderson, 2003). Epidemiological studies have reported a negative correlation between per capita fiber consumption and the incidence of chronic constipation (Graham et al., 1982). Dietary fibers from whole grains, fruits, and vegetables (including legumes) increase stool weight, which promotes normal laxation in children and adults. In general, the greater the weight of the stool, the more rapid the rate of passage through the colon (Birkett et al., 1997), and the better the laxative effect. The water-holding capacity and bulking ability that result in increased laxation are thought to reduce intracolonic pressure and lower the risk for diverticular disease as well (Bodribb and Humphreys, 1976).

Several factors affect stool weight, including the fermentability of the fiber (the less fermentable, the greater the fecal bulk), the water-holding capacity of the fiber, and the contribution of the fiber to microbial mass, which also contributes to fecal bulk (Bach Knudsen et al., 1997; Blackwood et al., 2000; Chen et al., 1998). In addition, certain fibers may contain unfermented gel, which acts as an emollient and a lubricant (Marlett et al., 2000). Cummings reviewed over 100 studies of the effect of fiber intake on stool weight and calculated the increase in weight of the stool as a function of fiber intake (Cummings et al., 1992). There was a wide range of the contribution of dietary fiber to fecal weight (e.g., an increase of 5.7 g fecal bulk per gram of wheat bran fed compared with an increase of 1.3 g per gram of pectin in the diet). A meta-analysis of 11 studies in which daily fecal weight was measured accurately in 26 groups of people ($n = 206$) on controlled diets of known nonstarch polysaccharide content shows a significant correlation between fiber intake and mean daily stool weight ($r = 0.84$) (Cummings et al., 1992). Although stool weight continues to increase as fiber intake increases (Burkitt et al., 1972; Wrick et al., 1983), there is a plateau effect for both intestinal transit time and fecal frequency. In general, most studies show that once intestinal transit time was less than 1 day and fecal frequency reached two to three per day, the only effect of extra fiber in the diet was increased stool weight

(Haack et al., 1998). The fecal weight required to achieve normalcy is variable, but the effect on decreasing transit time appears to plateau at fecal outputs >160 to 180 g per day (Burkitt et al., 1972). Many fiber experts have interpreted this as fiber having a "normalizing" effect on laxation: once normal laxation has been achieved, additional fiber may contribute to other health benefits but not to laxation.

A number of recent feeding studies of healthy individuals provide further evidence to support the role of a fiber-rich diet in normal laxation and other purported benefits to colonic health (Bach Knudsen et al., 1997; Blackwood et al., 2000; Chen et al., 1998; Haack et al., 1998). There are a large number of recent publications on the use of pre- and probiotics to alter the colonic microflora. Although a change in the microflora has been documented in several studies, functional endpoints are lacking at this time (Cummings et al., 1992). Certain clinical studies have reported successful management of chronic constipation with fiber supplementation (Cummings, 1984; Hein et al., 1978; Loening-Baucke, 1994; Shafik, 1993).

Children—Consumption of adequate dietary fiber is associated with important health benefits throughout the life cycle, but certain populations may require specific comment. For example, since the new AI for fiber is based on a decreased risk for CHD, some may assume that meeting the AI for fiber is less important for children than for adults. However, chronic constipation is one of the most common causes of morbidity in childhood (Bakwin and Davison, 1971; Leung et al., 1996; Loening-Baucke, 1995). Some studies have shown that up to 10 percent of children have chronic constipation (Bakwin and Davison, 1971; Leung et al., 1996; Loening-Baucke, 1995), which accounts for 25 percent of visits to pediatric gastroenterology clinics (Loening-Baucke, 1994). Several cross-sectional surveys on U.S. children and adolescents found inadequate dietary fiber intakes (Champagne et al., 2004; Cavadini et al., 2000). A randomized study of Greek children (291 with constipation and 1,602 controls) age 2 to 14 found that constipated children had lower caloric and nutrient intakes ($p < 0.001$), lower body weight/height ($p < 0.001$), and reported a higher prevalence of anorexia ($p < 0.001$). Despite the age of onset of constipation, dietary fiber alone was inversely correlated with chronic constipation ($p < 0.001$) (Roma et al., 1999). Another study found that children with constipation consumed approximately half as much fiber as a control group that was not constipated (McClung et al., 1995). Similarly, Morais et al. (1999) reported that children with chronic constipation ate less fiber than their age-matched counterparts.

Older Adults—There are a number of issues regarding healthy laxation and older adults, some of which are summarized in Imershein et al. (2000). Some of these issues involve varied definitions of what constitutes normal laxation. However, there are also very real issues of drug interactions with laxation and lack of appropriate hydration due to concerns about urinary incontinence. Diuretics (often prescribed for hypertension) may result in hard stools, which are difficult to pass. Limitations on mobility also contribute to constipation. Not only is the prevalence of constipation higher in older adults than in the general population (Grant, 1999), but the impact on quality of life appears to be greater (Pettigrew et al., 1997). Constipation may affect up to 20 percent of people over age 65 (Rouse and Mahapatra, 1991).

Fiber and CHD—Evidence from a large number of epidemiological studies supports a protective role for dietary fiber against CHD (Fraser et al., 1992; Humble et al., 1993; Kromhout et al., 1982; Kushi et al., 1985; Khaw and Barrett-Connor, 1987; Liu et al., 1999; Morris et al., 1977; Pietinen et al., 1996; Rimm et al., 1996; Wolk et al., 1999). The actual numbers used to set the AI were from three well-designed, adequately powered prospective epidemiological studies that measured the intake of fiber in healthy people and related the intake to later development of CHD (Pietinen et al., 1996; Rimm et al., 1996; Wolk et al., 1999). (See Table D5-1.) Specifically, in the *Health Professionals Follow-up Study*, in which 43,757 men were followed, the relative risk for CHD for men in the highest quintile of fiber intake was 0.59 compared with 1.0 for the men in the lowest quintile of fiber intake ($p < 0.001$). In the *Nurses' Health Study*, involving 68,782 U.S. women, the relative risk for the highest quintile of fiber intake was 0.77 compared with 1.0 for the lowest (Wolk et al., 1999). In the *Finnish Men's Study*, involving 21,930 men, the relative risk for CHD for men in the highest quintile of fiber intake was 0.45 compared with the lowest quintile ($p < 0.001$) (Pietinen et al., 1996). As can be determined from data rows one through three of Table D5-1, the AI of 14 g of fiber per 1,000 kcal was calculated using the average intake of fiber in the "protected group" in each of the studies (i.e., the highest quintile of fiber intake) and dividing that intake by the average energy intake for that quintile to obtain grams of fiber per calorie. Fiber intake then was expressed as grams per 1,000 calories to provide a more useable number. In brief, to be in the group with the lowest risk for CHD, an average intake of 14 g of fiber per 1,000 kcal would need to be consumed.

Table D5-1. Dietary fiber intake and coronary heart disease (CHD): Prospective cohort studies (The first 3 citations were used to establish AI for fiber in DRI Macronutrient report.)

Reference	Study Design	Quintile	Relative Risk for All or Fatal CHD	Dietary Fiber Intake (g/d)	Energy Intake (kcal/d)	Dietary Fiber (g/1000 kcal)
Pietinen et al., 1996	21,930 Finnish	1	1.00	16.1	2,722	5.9
	men, 50–69 y	2	0.87	20.7	2,787	7.4
	6-y follow-up	3	0.78	24.3	2,781	8.7
		4	0.67	28.3	2,754	10.3
		5	0.68	34.8	2,705	12.9
			$P < 0.001$			
Rimm et al., 1996	43,757 U.S.	1	1.00	12.4	2,000[a]	6.2
	men, 40–75 y	2	0.97	16.6	2,000	8.3
	6-y follow-up	3	0.91	19.6	2,000	9.8
		4	0.87	23.0	2,000	11.5
		5	0.59	28.9	2,000	14.45
			$P < 0.001$			
Wolk et al., 1999	68,782 U.S.	1	1.00	11.5	1,600[a]	7.2
	women,	2	0.98	14.3	1,600	8.9
	37–64y,	3	0.92	16.4	1,600	10.25
	10-y follow-up	4	0.87	18.8	1,600	11.75
		5	0.77	22.9	1,600	14.31
			$P = 0.07$			
Liu et al., 2002	39,876 U.S.	1	1.00	12.5	1,707	7.32
	women,	2	0.71	15.7	1,742	9.13
	45–75 y;	3	0.72	18.2	1,752	10.39
	Women's Health	4	0.64	21.1	1,734	12.10
	Study	5	0.65	26.3	1,694	15.52
	6-y follow-up		$P = 0.001$			
Bazzano et al., 2003	9,776 U.S. adults,	1	1.00	5.8	1,794	3.23
	NHANES 19-y	2	01.01	10.0	1,836	5.44
	follow-up	3	0.91	13.1	1,713	7.64
		4	0.88	22.2	1,596	13.90
		(quartiles)	$P = 0.05$			
Mozaffarian et al., 2003	3,588 U.S. men	1	1.00	<9.7[b]	1,820[a]	<5.32
	and women,	2	0.95	9.7–13.2	1,820	5.32–7.25
	≥ 65 y;	3	0.90	13.5–17.6	1,820	7.41–9.67
	10-y follow-up	4	0.92	17.9-23.0	1,820	9.84–12.64
		5	0.77	>23.0	1,820	>12.64
			$P = 0.3$			

[a] Dietary fiber intake is adjusted to caloric intake.

[b] Total dietary fiber derived by adding values for cereal, vegetable, and fruit fiber.

Two more recent prospective cohort studies (Bazzano et al., 2003; Liu et al., 2002) provide further evidence that supports the AI of 14 g of fiber per 1,000 kcal (Table D5-1). Liu et al. used prospective data from the *Women's Health Study* over a 6-year period to assess the relationship among total dietary fiber, soluble and insoluble fiber, and fiber sources on the risk of cardiovascular disease or myocardial infarction. A significantly smaller number of cardiovascular disease cases occurred in the highest quintile of intake than in the lowest quintile of intake (99 cases vs. 140 cases). The age and randomized treatment-adjusted relative risk (RR) of cardiovascular disease was 0.65 (p for the linear trend = 0.001) comparing the highest and lowest quintiles (Liu et al., 2002). Liu et al. also reported a pooled analysis of nine published dietary fiber and CHD epidemiological studies. This pooled analysis shows an RR of 0.83 associated with 10 g increases in dietary fiber intake (Liu et al., 2002). Bazzano et al. (2003) examined the relationship between total and soluble dietary fiber intake and the risk of CHD and cardiovascular disease in 9,776 adults who participated in the *National Health and Nutrition Examination Survey 1 Epidemiologic Follow-up Study*. They report that individuals in the highest quartile for dietary fiber intake (20.7 g per day) had an RR of 0.88 for CHD events compared with those in the lowest quartile (5.9 g per day).

A meta-analysis by Pereira et al. (2004) compared intakes of dietary fiber and its subtypes (cereal, fruit, and vegetable fibers) and risk of CHD. This pooled analysis of 10 large prospective studies reported that each 10 g per day increment of dietary fiber was associated with a 14 percent decreased risk of coronary death. Fiber from cereals and fruits also had a strong inverse association with CHD risk (RR 0.75 and 0.70, respectively). This association was not found for vegetable fiber (RR 1.00).

When setting the AI for fiber, the IOM also took into consideration small-scale clinical intervention trials and potential mechanisms for this observed protective effect against CHD. As reviewed by Fernandez (2001), a large number of relatively small-scale clinical intervention trials have shown that viscous fibers can lower serum cholesterol. It is generally accepted that a decrease in serum cholesterol is protective against CHD. (See Part D, Section 4, for further information.) Notably, in the studies in the Types and Sources of Dietary Fiber Summary Tables, Appendix G-3, *total* dietary fiber from foods was shown to be protective against CHD, not just those fibers that lower cholesterol. Whole grains, fruits, and vegetables are the food sources of fiber. Other possible mechanisms for the protective effect of high fiber diets include the delayed absorption of macronutrients, a decrease in serum triglyceride levels, and a lowering of blood pressure. Also, whole grains, fruits, and vegetables contain substances, such as phytochemicals, that may contribute to their beneficial effect in protecting against CHD.

Summary

Carbohydrates—the sugars, starches, and fibers found in grains, fruits, vegetables, and milk products—are an important part of a nutritious, healthy diet. The intake of carbohydrates (including sucrose, glucose, fructose, lactose, and starch) contributes to dental caries by providing substrate for bacterial fermentation in the mouth. Drinking fluoridated water and/or using fluoride-containing dental hygiene products help reduce the risk of dental caries.

Compared with individuals who consume small amounts of foods and beverages that are high in added sugars, those who consume large amounts tend to consume more calories but smaller amounts of micronutrients. Although more research is needed, available prospective studies suggest a positive association between the consumption of sweetened beverages and weight gain. A reduced intake of added sugars (especially sugar-sweetened beverages) may be helpful in weight control and in achieving recommended intakes of nutrients.

To reduce the risk of CHD disease and promote healthful laxation, the Committee recommends the intake of 14 g of dietary fiber per 1,000 calories.

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Section 6: Selected Food Groups (Fruits and Vegetables, Whole Grains, and Milk Products)

The Committee focused attention on fruits and vegetables, whole grains, and milk products because of the growing body of research linking them to health and because intake of these food groups by many Americans is far below previous recommendations. The fruit and vegetable groups are combined because they are examined together in much of the scientific literature related to health outcomes. This section addresses three major questions related to food groups and health:

1. What are the relationships between fruit and vegetable intake and health?
2. What are the relationships between whole-grain intake and health?
3. What are the relationships between milk product intake and health?

The other basic food group (meat, poultry, fish, and legumes) is covered in Section 1, "Meeting Recommended Nutrient Intakes," and fish also is covered in the "Fats" and "Food Safety" sections.

Question 1: What Are the Relationships Between Fruit and Vegetable Intake and Health?

Conclusions

Greater consumption of fruits and vegetables (5 to 13 servings or 2½ to 6 ½ cups per day, depending on calorie needs) is associated with a reduced risk of stroke and perhaps other cardiovascular diseases, with a reduced risk of cancers in certain sites (oral cavity and pharynx, larynx, lung, esophagus, stomach, and colon-rectum), and with a reduced risk of type 2 diabetes (vegetables more than fruit). Moreover, increased consumption of fruits and vegetables may be a useful component of programs designed to achieve and sustain weight loss.

Rationale

Fruits and Vegetables and Cardiovascular Disease

Overview—The conclusion related to cardiovascular disease (CVD) is based on the Committee's review of evidence from an extensive literature view covering prospective, observational studies; other observational studies that addressed whole patterns of food consumption; and trials of the effects of fruit and vegetable consumption on blood pressure. Fruits and vegetables are associated with a reduction in CVD through a variety of mechanisms. First, they provide nutrients, such as fiber, folate, potassium, and carotenoids and other phytochemicals that may directly reduce CVD risk. Second, certain nutrients may directly improve established, diet-related CVD risk factors, such as blood pressure, hyperlipidemia, and diabetes. Third, the consumption of fruits and vegetables may lead to a reduced intake of saturated fat and cholesterol. Therefore, it is plausible to hypothesize that diets rich in fruits and vegetables should reduce the risk of CVD.

Several review articles have summarized the evidence from prospective observational studies (Bazzano et al., 2003; Law and Morris, 1998; Ness and Powles, 1997). The review by Bazzano included 10 prospective studies. In 7 of the 10 studies, an increased intake of fruits and vegetables was associated with a significant reduction in at least one CVD outcome; in pooled analyses of these studies, the relative risk of CVD (highest to lowest categories of fruit and vegetable intake) was 0.82 (95 percent CI: 0.76 to 0.89). Since then, four other major studies were published (Johnsen et al., 2003; Rissanen et al., 2003; Sauvaget et al., 2003; Steffen et al., 2003). The two studies that examined the relationship of fruit and vegetable intake with CVD mortality documented a significant inverse relationship (Rissanen et al., 2003; Steffen et al., 2003). In six of the seven studies that examined the relationship of fruit and vegetable intake with stroke, there was a significant inverse relationship (Bazzano et al., 2002; Gillman et al., 1995; Johnsen et al., 2003; Joshipura et al., 1999; Rissanen et al., 2003; Sauvaget et al., 2003; Steffen et al., 2003). Only three studies examined the relationship of fruit and vegetable intake with coronary heart disease (CHD) (Bazzano et al., 2002; Joshipura et al., 2001; Steffen et al., 2003); an inverse relationship was documented in only one study (Joshipura et al., 2001). In most studies, the results were attenuated in models that included CVD risk factors. This pattern of results suggests that at least part of the beneficial effects of fruit and vegetable intake is mediated through CVD risk factors. In most studies

that documented a significant relationship, the general pattern of results appeared be a progressive, inverse relationship rather than a threshold relationship.

Other observational studies have examined the relationship between whole patterns of food consumption and CVD. Often these studies use factor analysis to identify clusters of foods that are commonly consumed together. In these studies, those dietary patterns associated with a reduced risk of CVD (invariably) are rich in fruits and vegetables (Fung et al., 2001; Hu et al., 2001; Millen et al., 2004).

To date, no trial has tested the effects of increased fruit and vegetable intake on clinical CVD outcomes (i.e., coronary heart disease events, stroke). However, some trials have assessed the effects of fruits and vegetables on CVD risk factors. Four trials tested the effects of increased fruit and vegetable intake on blood pressure. Two of these trials documented that increased fruit and vegetable intake can lower blood pressure (Appel et al., 1997; John et al., 2002). Mean systolic blood pressure/diastolic blood pressure reductions were 2.7/1.9 mmHg and 4.0/1.5, respectively. All reductions were significant. In the two other trials, both of which were smaller or less well controlled, increased fruit and vegetable intake did not lower blood pressure (Broekmans et al., 2001; Smith-Warner et al., 2000). Finally, two trials tested the effects of fruits and vegetables in the context of multifactorial interventions on blood pressure (Appel et al., 2003; Sacks et al., 2001). In both studies, the multifactorial interventions significantly lowered blood pressure. Based on extensive research documenting that increased potassium intake reduces blood pressure (Whelton et al., 1997), at least part of the beneficial effect of increased fruit and vegetable intake on blood pressure results from increased potassium consumption. In summary, prospective observational studies have documented that increased fruit and vegetable intake is associated with a reduced risk of stroke and perhaps other cardiovascular diseases. Clinical trials have documented that an increased intake of fruits and vegetables can lower blood pressure.

Fruits and Vegetables and Cancer Prevention

Overview—The conclusion pertaining to fruit and vegetable intake and cancer prevention is based on the Committee's consideration of published evidence-based reviews focusing on the relationship between consumption of fruits and vegetables and cancer risks. These reviews were conducted by expert panels of the World Cancer Research Fund and American Institute for Cancer Research (WCRF/AICR, 1997), the National Cancer Institute (NCI) (*http://cancer.gov/cancerinfo/pdq/prevention*), and the World Health Organization (WHO) International Agency for Research on Cancer (IARC, 2003) (*IARC Handbook of Cancer Prevention on Fruits and Vegetables*). All expert panels followed a similar process of reviewing international evidence-based literature, primarily epidemiological studies, including case-control and prospective cohort studies and controlled trials with meta-analyses and pooled analyses to establish the strength of the evidence.

It has now been established that cancer results from the interaction of human genes with environmental factors such as tobacco use; dietary factors, including low fruit and vegetable consumption and high red meat and fat intake; and lifestyle issues such as physical inactivity and obesity (WCRF/AICR 1997). Individuals who consume diets rich in fruits and vegetables may be at lower risk for certain cancers, particularly cancers of the gastrointestinal tract. The WHO IARC has estimated that low fruit and vegetable intake contributes to 5 to 12 percent of all cancers and up to 20 to 30 percent of upper gastrointestinal cancers that may otherwise be preventable. Therefore, the consumption of fruits and vegetables can confer protection against cancer. The phytochemical components in fruits and vegetables possess anticarcinogenic properties that influence DNA damage and repair, thus reducing mutations. These phytochemicals include antioxidants such as carotenoids and vitamin C, flavanoids, isothiocyanates, and organosulfides, as well as minerals and other bioactive compounds (Liu et al., 2003b). In addition, fruits and vegetables provide fiber, which helps decrease gut transit time and binds potential carcinogenic agents, secondary bile acids, and short-chain fatty acids (WCRF/AICR, 1997).

Review of the Evidence—In 1997, the WCRF/AICR expert panel provided key evidence that dietary protection against cancer is strongest and most consistent for diets high in vegetables and fruits, particularly in relation to cancers of the mouth and pharynx, esophagus, stomach, colon-rectum (vegetables only), and lung (WCRF/AICR, 1997). The National Cancer Institute's PDQ® (Physician Data Query) at *http://cancer.gov/cancerinfo/pdq/prevention* subsequently confirmed these findings. This database formed the basis of the NCI's National 5-A-Day Program (*http://www.5aday.gov*).

The WHO IARC published the findings of its working group's extensive review in the *IARC Handbook of Cancer Prevention on Fruit and Vegetables* (2003). The IARC working committee evaluated the evidence

gathered on certain cancer sites in relation to intake of total fruits or total vegetables. Few of the identified studies had examined the effects of the total combined intake of fruits and vegetables. The world literature was reviewed and grouped together based on study design—either randomized-controlled trials, cohort studies, or case-control studies. The expert panel also considered the selection bias, confounding factors, measurement errors, and other variables. Human studies were included in the IARC evaluation only if the reports provided estimates of risk for total fruit or for total vegetable consumption and 95 percent confidence intervals were available. Estimates of a weighted mean of the reported relative risks were calculated. Evidence tables have been constructed for each cancer site, and meta-analyses and pooled analyses are presented. The results of this analysis of cancer sites are published in the IARC's handbook. The IARC concluded there is evidence of cancer preventive effects with increased consumption of fruits and vegetables for cancers of the mouth, pharynx, esophagus, colon-rectum, larynx, stomach, and lung. There is inadequate evidence of a cancer-preventive effect of fruit and vegetable consumption for all other cancer sites. The number of studies, mean odd ratios, and the 95 percent confidence intervals on some of the cancer sites are listed below in Tables D6-1 and D6-2.

In addition, the preventive effects of fiber on colorectal cancer were demonstrated recently in a prospective study conducted by the European Prospective Investigation Into Cancer and Nutrition Group (EPIC). Results showed that doubling total fiber intake from the current average level in most populations (about 20 g per day) may reduce the risk of colorectal cancer, particularly colon cancer. About eight portions (rather than just five) of fruits and vegetables would need to be consumed per day, along with the equivalent of five slices of whole-grain bread (Riboli and Norat, 2003).

Recommendations from Other Groups—Agencies of the Federal Government, preventive health organizations, and world bodies have recommended an increased intake of a variety of fruits and vegetables to five to nine servings per day, or 400 to 800 g of fruits and vegetables per day (NCI Web site: *http://cancer.gov/cancerinfo/pdq/prevention*; WCRF/ AICR, 1997; IARC, 2003). Adherence to the AICR cancer prevention recommendations investigated in the *Iowa Women's Health Study Cohort* have substantial impact on reducing cancer incidence, with population attributable risks (avoidable risk) of 22 percent (95 percent CI, 12–30) for cancer incidence and 11 percent (95 percent CI, 4-24) for cancer mortality (Cerhan et al., 2004).

Fruits and Vegetables and Type 2 Diabetes Mellitus

The conclusion relating to the relationship of fruit and vegetable intake with diabetes is based on the Committee's review of cross-sectional and prospective studies as described below. The roles of fruits and vegetables tend to be associated with those of fiber in the prevention of type 2 diabetes, making them difficult to distinguish. Dietary fiber tends to lower postprandial glucose response (Anderson and Akanji, 1991). Diets high in complex carbohydrates have been shown to protect against type 2 diabetes, and this has been ascribed in some studies to their high fiber content (Yang et al., 2003).

Table D6-1. Case-control studies of fruit or vegetable consumption and their cancer preventive effects*

Parameters	**Cancer Sites**				
	Oral/Pharyngeal	**Esophagus**	**Stomach**	**Colorectal**	**Larynx**
Fruits					
Number of studies	10	19	34	15	4
Mean odds ratios	0.45	0.54	0.63	0.87	0.63
Range (95% CI)	0.38–0.53	0.48–0.61	0.59–0.69	0.78–0.97	0.52–0.77
Vegetables					
Number of studies	7	12	23	18	4
Mean odds ratios	0.49	0.64	0.66	0.63	0.49
Range (95% CI)	0.39–0.62	0.57–0.72	0.61–0.71	0.56–0.70	0.40–0.61

*Source of data: IARC Handbooks of Cancer Prevention, Vol. 8: Fruit & Vegetables.

Table D6-2. Cohort studies of fruit or vegetable consumption and their cancer preventive effects*

Parameters	Cancer Sites				
	Oral/Pharyngeal	**Esophagus****	**Stomach**	**Colorectal**	**Larynx**
Fruits					
Number of studies	3	10	19	16	5
Mean odds ratios	Individual studies: 0.99 0.9 0.57	0.85	1.00	0.77	0.87
Range (95% CI)	Individual studies: 0.85–1.15 0.8–1.1 0.31–1.04	0.77–0.95	0.96–1.05	0.71–0.84	0.72–1.04
Vegetables					
Number of studies	4	6	16	14	3
Mean odds ratios	Individual studies: 1.06 0.66 0.8 0.89	0.94	0.97	0.80	0.94
Range (95% CI)	Individual studies: 0.91–1.24 (90% CI) 0.44–0.99 0.6–1.0 0.48–1.63	0.84–1.06	0.87–1.08	0.73–0.88	0.76–1.16

*Source of data: IARC Handbooks of Cancer Prevention, Vol. 8: Fruit & Vegetables.
**Data were not pooled for analysis.

Review of the Evidence—Ford et al. (2000) examined whether fruit and vegetable consumption was associated with type 2 diabetes incidence in a cohort of U.S. adults age 25 to 74 years who were followed for about 20 years. After adjustment for a large number of variables, the hazard ratio for participants consuming five or more servings of fruits and vegetables per day compared with those consuming none was 0.73 for all participants, 0.53 for women, and 1.14 for men. Thus, these investigators found conflicting results in men and women. Williams and colleagues (1999) have shown that frequent intakes of raw and salad vegetables are protective against type 2 diabetes. However, in the same study, they did not find a significant association between fruits and diabetes. A subsequent study in the same cohort showed that a higher intake of both fruits and vegetables is associated with a lower risk for having glucose intolerance and undiagnosed diabetes (Williams et al., 2000). Gittelsohn et al. (1998) also reported that a higher intake of fruits and vegetables was associated with a lower prevalence of diabetes.

In a cross-sectional study of a large population-based cohort not known to have diabetes, a report from the EPIC group (Sargeant et al., 2001) showed that those individuals who reported never or seldom having both fruit and green leafy vegetables had higher mean HgbA1c measurements (5.43 percent) than those who reported more frequent consumption (5.34 percent). These differences were not substantially changed after controlling for dietary fiber or for vitamin C. This lends support to the hypothesis that a high intake of fruits and green leafy vegetables may influence glucose metabolism and may contribute to the prevention of diabetes. These investigators carefully excluded participants with a diagnosis of diabetes, who may have changed their diet and lifestyle as a result of their diagnosis.

In a prospective study of middle-aged men, increased consumption of vegetables and legumes was inversely associated with 2-hour glucose level (Feskens et al., 1995). In the *Nurses' Health Study* (Colditz et al., 1992) the risk of diabetes was inversely related to vegetable but not to fruit consumption. Another longitudinal observational study of 20-year duration (Snowdon and Phillips, 1985) also reported a lower incidence of diabetes in those individuals who increased their intake of fruits and vegetables during the follow-up period. Some studies, however, have shown no effect (Lundgren et al., 1989; Salmeron et al., 1997a, 1997b). On the other hand, no study has found a harmful effect of fruit and vegetable consumption on the development of diabetes. Van Dam et al. (2002) reported on two major dietary patterns and the risk of type 2 diabetes in the *Male Health Professionals* study. They found that a prudent diet, characterized by a higher consumption of vegetables, fruit, fish, poultry, and whole grains, was associated with a significantly decreased risk for the development of diabetes as compared with a western diet characterized by a higher consumption of red meat, processed meat, French fries, high-fat dairy products, refined grains, and sweets and desserts.

Recommendations from Other Groups—Consistent with the above, current nutrition recommendations from the American Diabetes Association and the WHO for the prevention of type 2 diabetes encourage the consumption of carbohydrate-containing foods such as whole grains, fruits, vegetables, and low-fat milk (Franz et al., 2002; Mann et al., 2002).

Fruits and Vegetables and Weight Status

Overview—The conclusion relating to the relationship of fruit and vegetable intake with weight status is based on the Committee's review of a number of observational studies, including only two prospective studies, and several different types of trials, as described below. Fruits and vegetables are high in water and fiber content and therefore low in energy density. These types of foods also may promote satiety and decrease energy intake. Therefore, it is plausible to hypothesize that diets rich in fruits and vegetables might prevent weight gain and facilitate weight loss.

Review of the Evidence—A relatively large number of observational studies have examined the relationship between fruit and vegetable consumption and weight (Bazzano et al., 2002; Drapeau et al., 2004; Flood et al., 2002; Gillman et al., 1995; Kobayashi et al., 2002; LaForge et al., 1994; Lahti-Koski et al., 2002; Lin and Morrison, 2002; Liu et al., 2000, 2001; Nicklas, 2003; Patterson et al., 1990; Rissanen et al., 2003; Serdula et al., 1996; Terry et al., 2001; Trudeau et al., 1998; Williams et al., 1999). However, most are cross-sectional studies, which limit causal inferences. Drapeau et al. (2004) reported that increases in the consumption of whole fruits in a cohort of 248 volunteers followed for approximately 6 years was associated with a lower increase in body weight with time. Only two prospective studies examined the relationship between fruit and/or vegetable consumption and change in body mass index (BMI). In one study, Kahn and colleagues (1997) followed 35,156 men and 44,080 women who participated in the *Cancer Prevention Study II* of the American Cancer Society. Over the course of 10 years, those men and women in the highest quintile of vegetable intake (> 19 servings per week) experienced a significant decrease in BMI (that is, a decline of 0.11 kg/m2 in men and 0.10 kg/m2 in women). Another prospective study (Field et al., 2003) assessed the effects of fruit and vegetable intake on changes in BMI over the course of 3 years of follow-up in 8,203 girls and 6,715 boys, age 9 to 14 years. In this study, neither fruits nor fruit juices predicted changes in BMI. Vegetable intake was inversely associated with BMI change in boys but not girls. This effect in boys was diminished and no longer statistically significant once total calories were included in the model. These findings suggest that the protective effect of vegetables was mediated through reduced calorie intake rather than the vegetables per se.

As reviewed by Rolls and colleagues (2004), several different types of trials have assessed the effects of increased fruit and vegetable intake on weight. In two uncontrolled studies, *ad libitum* provision of a traditional Native Hawaiian diet, which is rich in fruits and vegetables, led to reduced weight in overweight Hawaiians. Several small trials that advised persons to increase fruit and vegetable consumption but did not advise them to lose weight documented no net effect on weight. (See Table 4 from Rolls et al., 2004.) Trials that advised persons to increase fruit and vegetable consumption and also to decrease fat intake, again without giving advice to lose weight, tended to show weight maintenance or net weight loss. (See Table 4 from Rolls et al., 2004.) Of interest is one trial that specifically tested the effects of fruits and vegetables on weight over 1 year (Djuric et al., 2002). In this randomized 2 by 2 factorial trial that tested the effects of (1) increased fruit and vegetable intake and (2) reduced fat intake, alone or combined, participants were counseled to maintain their energy intake while they made the dietary changes relevant to their assigned group. The group assigned to increase their fruit and vegetable group without reducing fat intake increased

fruit and vegetable consumption from about 4 to 11 servings per day and increased their energy intake by approximately 170 kcal per day. This group increased their weight by 4 pounds. Those assigned to the reduced fat group alone reduced their weight by 11 pounds, while those assigned to both increased intake of fruits and vegetables and reduced fat had no change in weight. In aggregate, these data indicate that in the absence of advice to lose weight, increased fruit and vegetable intake by itself does not lead to weight loss.

Most relevant are those trials that attempted weight loss through increased fruit and vegetable consumption, often combined with reduced calorie intake, typically with a focus on decreased fat intake. The largest and longest study to examine this issue documented the effects of a cardiovascular risk reduction intervention that attempted to improve blood pressure and lipid control (Stamler and Dolecek, 1997). In this trial, 6,248 men were advised to lose weight. Several dietary changes predicted sustained weight loss, including greater intakes of fruit and vegetables.

Another clinical trial, PREMIER (Appel et al., 2003), tested the effects of two different behavioral intervention programs to lower blood pressure, in part through weight loss. One intervention emphasized calorie reduction, reduction in fat intake to less than 30 percent energy, and increased physical activity. The other intervention emphasized the Dietary Approaches to Stop Hypertension (DASH) diet, which is rich in fruits and vegetables and further reduced fat intake (< 25 percent energy). After 6 months of intervention, mean fruit and vegetable intake was nearly 8 servings per day in the group that received advice on the DASH diet but only about five servings per day in the other group. Corresponding net weight loss was 12.8 lb and 10.8 lb, respectively, but the difference between the groups was not statistically significant ($p = 0.08$). Two uncontrolled studies documented that a low-fat, low-energy density diet that allowed unlimited intake of fruits and vegetables led to sustained weight loss. In the first study with an average follow-up period of 17 months (Weinsier et al., 1982), 44 percent of individuals continued to lose weight and 92 percent remained below their baseline weight. A similar pattern was evident in the second study by this group with 25 months of followup (Fitzwater et al., 1991).

Overall, available data suggest that increased consumption of fruits and vegetables may be a useful component of programs designed to achieve and sustain weight loss. However, there are limited data that increased consumption of fruits and vegetables prevent weight gain in the first place.

Intakes of Fruits and Vegetables

Daily servings of fruits and vegetables for individuals 2 years of age and older remained similar from an average total of 4.5 servings in 1989–1991 to 4.9 servings in 1994–1996; they decreased slightly to 4.7 servings in 1999–2000 (NCI Web site: *http://cancer.gov/cancerinfo/pdq/prevention*). Daily vegetable intake increased from 3.2 to 3.4 servings, then decreased to 3.2 servings. On average, total vegetable intake included 0.3 servings of dark green/deep yellow vegetables, 1.4 servings of starchy vegetables (primarily fried potatoes), and 1.5 servings of tomatoes and other vegetables. Fruit intake increased from 1.3 to 1.5 servings over the same timeframe. Neither trend is considered statistically significant. Vegetable consumption tends to increase as individuals age, but fruit consumption is highest among the very young and oldest individuals in the population. Individuals of lower education and income levels tend to eat fewer servings of vegetables and fruit than do those with more education and higher income. According to national surveys, African Americans tend to have the lowest intakes of fruits and vegetables among ethnic and racial groups (HHS, 2004; USDA, 2004).

Question 2: What Are the Relationships Between Whole Grain Intake and Health?

Conclusion

Consuming at least three servings (equivalent to 3 ounces) of whole grains per day can reduce the risk of diabetes and CHD and helps with weight maintenance. Thus, daily intake of 3 ounces of whole grains per day is recommended, preferably by substituting whole grains for refined grains.

Rationale

Overview

The conclusion is based on the Committee's review of scientific evidence from 46 published papers pertaining to CHD, diabetes, and obesity. The recommended number of whole-grain servings is based on evidence presented in 12 large prospective studies, which are presented in Appendix G-3.

Whole grains and foods made from them consist of the entire grain seed, usually called the kernel. The kernel is made of three components—the bran, the germ, and the endosperm. If the kernel has been cracked, crushed, or flaked, then it must retain nearly the same relative proportions of bran, germ, and endosperm as the original grain to be called whole grain (AACC et al., 2004). In the grain-refining process, most of the bran and some of the germ is removed, resulting in the loss of dietary fiber (also known as cereal fiber), vitamins, minerals, lignans, phytoestrogen, phenolic compounds, and phytic acid (Slavin, 2003). Most refined grains are then enriched with thiamin, riboflavin, iron, and niacin to restore these nutrients to levels found in the grain prior to refining. Enriched refined grains products are required by law to be fortified with folic acid, but whole-grain foods are not required to be fortified with folic acid (*Federal Register*, 1996). However, food manufacturers may fortify whole-grain foods where regulations permit the addition of folic acid. Currently, a number of ready-to-eat whole-grain breakfast cereals are fortified with folic acid.

Important grains in the U.S. diet include wheat, rice, maize, and oats. The average intake of whole grains is less than 1 serving per day; less than 10 percent of Americans consume three servings per day (Cleveland et al., 2000). In a study of whole-grain consumption by U.S. children and adolescents using data from the 1994–1996 *Continuing Survey of Food Intake by Individuals* (CSFII), the average whole-grain intake ranged from 0.8 servings per day for preschool-aged children to 1.0 servings per day for adolescents (Harnack et al., 2003). Ready-to-eat cereals, corn or tortilla chips, and yeast breads were the major sources of whole grains (30.9 percent, 21.7 percent, and 18.1 percent respectively).

Whole Grains and Risk of Coronary Heart Disease

Whole-grain intake has been found to be consistently associated with a reduction in the risk of CHD among both men and women (see Appendix G-3) (Jacobs et al., 1998, 1999; Jensen et al., in press 2004; Liu et al., 1999, 2002; Pietinen et al., 1996; Rimm et al., 1996; Steffen et al., 2003). Collectively, the studies suggest a 20 to 30 percent reduced risk of CHD with three or more servings of whole-grain foods per day. For example, in the *Nurses' Health Study*, which documented 761 cases of CHD in 75,521 women, increased whole-grain intake was associated with decreased risk of CHD. Women in the highest quintile of intake had a relative risk of 0.51 ($p < 0.0001$) compared with those in the lowest quintile (Liu et al., 1999). In the *Iowa Women's Health Study* (Jacobs et al., 1998), which involved 34,492 postmenopausal women followed for 6 years, a greater intake of whole grain was associated with a reduced risk of CHD death (RR = 0.67 comparing the highest quintile with the lowest quintile of intake). In the *Health Professionals Study* (all men) (Jensen et al., in press 2004), men in the highest quintile for whole-grain intake had a RR of 0.64 for CHD compared to those in the lowest quintile of whole-grain intake. Although adjustment for potential confounders and risk factors for CHD other than BMI attenuated this association (Hazard Ratio [HR] = 0.82; p for trend = 0.01), each 20 g increment in whole-grain consumption corresponded to a 6 percent reduction in CHD risk (Jensen et al., in press 2004).

Certain studies base their evaluation of the strength of the relationship between whole-grain intake and reduced risk of CHD on the consumption of specific food groups or foods that are high in whole grains. For example, the *Adventist Health Study* (Fraser et al., 1992) reported an inverse association between intake of whole wheat bread and risk of myocardial infarction in 31,208 Seventh-Day Adventists (RR = 0.56 for nonfatal myocardial infarction in those consuming whole wheat compared with white bread). Whole-grain bread intake also has been associated with a reduced incidence of CHD (Jacobs et al., 2001). Similarly, intake of breakfast cereals with a high whole-grain content also has been associated with a reduced incidence of CHD (Liu et al., 2003a).

Fiber and the Observed Protective Effect of Whole Grain

Because dietary fiber is an important component of whole grains and the fiber content is greatly reduced when grains are refined, the literature on fiber and CHD also is applicable to the protective role of whole grains against CHD. (See "Rationale" for Question 1 on fiber and CHD above.) In brief, intake of high fiber foods has been independently associated with reduced incidence of ischemic heart disease and stroke (Humble et al., 1993; Khaw and Barrett-Connor, 1987; Pietinen et al., 1996; Rimm et al., 1996; Wolk et al., 1999).

Mozaffarian et al. (2003) determined whether fiber consumption from fruit, vegetable, and cereal sources (including whole grains and bran) is associated with incident CVD in older adults. During 8.6 years of follow-up in 3,588 men and women age 65 years and older at baseline, cereal fiber consumption was inversely associated with incident CVD ($p = 0.02$). The relative risk was 0.79 in the highest quintile of intake compared with the lowest quintile. Neither fruit fiber intake nor

vegetable fiber intake was associated with CHD incidence (Mozaffarian et al., 2003). This finding of a protective effect of fiber from cereals, but not from fruits or vegetables, is consistent with results from other studies (Pietinen et al., 1996; Rimm et al., 1996; Wolk et al., 1999) and supports the importance of whole-grain consumption as protective against CHD risk.

A number of studies assessing the relationship between whole-grain consumption and risk of CHD have evaluated the relationship of fiber intake and CHD risk in the same population. For example, the report on the *Nurses' Health Study* (Liu et al., 1999) evaluated whether the association of whole-grain intake with CHD risk could be attributed to its constituents (e.g., dietary fiber, folate, vitamin B6, and vitamin E) or if something other than the micronutrient and fiber content of the whole grain was correlated with the protective effect. When the investigators adjusted for these protective factors, the significant inverse relationship of whole-grain intake to CHD risk was still evident. They suggest that this implies either a synergistic effect of the protective factors in whole grains or an effect from other substances, as yet unidentified, in whole grains. When the investigators for the *Health Professionals Study* looked at bran (a component of whole grain) and CHD risk, they found that the inverse association of bran and CHD was even stronger than that for whole grain. The HR of CHD among men with the highest intake of added bran was 0.70 compared with that among men with no intake of added bran ($p = <0.001$) (Jensen et al., in press 2004). The authors conclude that their study supports the reported beneficial association of whole-grain intake and CHD, and it suggests that the bran component of whole grains could be a key factor in this relationship. However, the inverse relationship between whole-grain consumption remained after adjusting for bran intake.

In the *Cardiovascular Health Study* (a population-based, multicenter study with 3,588 men and women age 65 and older), cereal fiber consumption was inversely associated with CHD ($p = 0.02$). Risk was 21 percent lower in the highest quintile of intake, compared with the lowest quintile. In similar analyses, neither fruit fiber intake ($p = 0.98$) nor vegetable fiber intake ($p = 0.95$) was associated with incidence of CHD (Mozaffarian et al., 2003).

Physiological Basis for a Relationship Between Whole-Grain Intake and Decreased Risk of CHD

Although well-conducted prospective cohort studies are important and valuable in determining associations between nutrient intake and risk of disease, there is more confidence in these results when they are supported by biologically plausible mechanisms for the observed effect. One potential mechanism by which whole grains may decrease risk of CHD is through their antioxidant content (Decker et al., 2002). Vitamin E is present in whole grains but removed in the refining process and not added back in the enriching process. Similarly, selenium is present in whole grains but not enriched grains (Miller, 2001). Other bioactive compounds in whole grains include lignans, phytoestrogens, phytosterols, and digestive enzyme inhibitors. Although it is difficult to sort out the beneficial effects of whole grains independent of some of their constituents such as fiber and antioxidants, Slavin makes a case that whole-grain consumption is protective beyond what would be predicted if the protection found with the individual compounds were simply additive (Slavin, 2003; Slavin et al., 2001).

Possible Confounders With Respect to Whole-Grain Intake and CHD Incidence

Compared with low consumers of whole-grain foods, high consumers may smoke less, exercise more, and be more likely to use supplements or multivitamins. Thus, whole-grain intake may be just a proxy for a healthy lifestyle. However, when any of these known confounders have been evaluated, the inverse relationship between whole-grain consumption and risk of CHD (although attenuated) still remains statistically significant (Jensen et al., in press 2004; Liu et al., 1999). Moreover, in the studies that have evaluated fiber as a confounder, whole-grain intake has still remained protective against CHD (Liu et al., 2000). In fact, an argument could be made that the beneficial effects observed with cereal fiber are really due to whole grains rather than to the fiber per se, since it is probable that the cereal fiber intake is closely reflective of the whole-grain intake. Studies that focus on whole grain or on cereal fiber as the exposure measurements are, therefore, often measuring approximately the same entity (Mozaffarian et al., 2003). In addition, problems specific to measuring whole-grain intake may hinder accurate interpretation of results. For example, often participants are asked how much dark bread they ate, but the whole-grain content of many dark breads is very low.

Whole Grains and Risk of Type 2 Diabetes

As with whole grains and CHD, major prospective epidemiologic studies show an inverse relationship between whole-grain consumption and the risk of type 2 diabetes. Three prospective studies in large numbers of men and women examined the relationship of whole-

grain or cereal-fiber intake with the risk of type 2 diabetes. Each study used a mailed food frequency questionnaire as well as self-reported diabetes diagnosis. Risk of incident diabetes was 21 to 27 percent lower for those in the highest quintile of whole-grain intake and 30 to 36 percent lower in the highest quintile of cereal-fiber intake, each compared with the lowest quintile (Liu et al., 2000; Salmeron et al., 1997a, 1997b). Risk reduction persisted after adjustment for the healthier lifestyle found among habitual whole-grain consumers.

Similarly, in the *Iowa Women's Health Study*, approximately 100,000 postmenopausal women were sampled and followed for 6 years. Meyer et al. (2000) examined the relationship of baseline intake of carbohydrate, fiber, and grains on the incidence of diabetes in this large cohort of women. Total grain, whole grain, total fiber, cereal fiber, and dietary magnesium intakes all showed strong inverse associations with incidence of diabetes after adjustment for potential nondietary confounding variables. Multivariate-adjusted relative risks of diabetes were 1.0, 0.99, 0.98, 0.92, and 0.79 ($p = 0.0089$) for whole grains and 1.0, 0.81, 0.82, 0.81, and 0.67 ($p = 0.0003$) for total fiber. Women who consumed the most whole grains (> 17.5 servings per week) had a 21 percent lower risk of diabetes compared with those with the lowest intakes of whole grains (< 3 servings per week) (Meyer et al., 2000). There was no significant effect of refined grains or fruits and vegetables.

Fung et al. (2001) examined prospectively the associations between whole- and refined-grain intake and the risk of type 2 diabetes among a large cohort of men in the *Health Professionals Follow-Up Study*. After adjustment for age, physical activity, cigarette smoking, alcohol consumption, family history of diabetes, and fruit, vegetable, and energy intakes, the relative risk of diabetes was 0.58 ($p \leq 0.0001$) comparing the highest with the lowest quintile of whole-grain intake. Intake of refined grains was not significantly associated with the risk of type 2 diabetes.

Whole-grain consumption was associated with a reduced risk of type 2 diabetes in the *Finnish Mobile Clinic Health Examination Survey* (Montonen et al., 2003). This survey consists of a cohort of 2,286 men and 2,030 women during a 10-year follow-up. The relative risk between the highest and lowest quartiles of whole-grain consumption was 0.65; $p = 0.02$.

In summary, the four prospective studies (*Iowa Women's Health, Nurses' Health, Health Professionals Follow-Up Study,* and the *Finnish Mobile Clinic Health Examination Survey*) all show a risk reduction for type 2 diabetes of 20 to 30 percent. For an excellent review on whole grains and risk of diabetes, see Murtaugh et al. (2003).

Physiological Basis for a Relationship Between Whole-Grain Intake and Decreased Risk of Diabetes

The results of the four epidemiological studies that used diabetes as the end point are supported by other studies using intermediate markers for diabetes. For example, plasma glucose and insulin values may supply information on mechanisms by which whole grains exert their protective effect. The Committee examined evidence of the relationship of whole-grain consumption to glucose and insulin levels included in a recent review (Murtaugh et al., 2003). Briefly, in one cohort of 3,627 individuals age 18 to 30 (the *Coronary Artery Risk Development in Young Adults* [CARDIA] study) whole-grain consumption was assessed at years 0 and 7 and compared with values at year 10 (Pereira et al., 1998). Whole-grain consumption was inversely related to fasting insulin values.

In a feeding study, Pereira et al. (2002) tested whether or not whole-grain consumption improves insulin sensitivity in overweight and obese adults. When whole-grain products replaced refined-grain products, fasting insulin decreased by 10 percent over 6 weeks. In the *Framingham Offspring Study* (McKeown et al., 2002), whole-grain consumption in the highest quintile (13 to 64 servings per week) was associated with a significant decrease in fasting insulin compared with the lowest whole-grain consumption (0 to 1.5 servings per week) after adjusting for known confounders ($p = 0.01$). This relationship was no longer significant after adjusting for total fiber. Also, whole-grain consumption has been inversely associated with BMI (McKeown et al., 2002), which is an independent risk factor for diabetes and CHD. (See section below.) The American Diabetes Association has concluded that some evidence supports the role of whole grain or dietary fiber in reducing the risk of type 2 diabetes (Franz et al., 2002).

Is the Observed Protective Effect of Whole Grain Due to Its Fiber Content?

Some of the published epidemiologic studies have found an inverse association between fiber intake and the occurrence of type 2 diabetes (Hu et al., 2001; Meyer et al., 2000; Montonen et al., 2003; Salmeron et al., 1997a, 1997b). For example, in the *Nurses' Health Study*, Salmeron et al. reported on fiber intake and its relationship to diabetes. The risk reduction was similar

to that of whole-grain intake in the same cohort (a 28 percent risk reduction from the highest to the lowest quintile of fiber intake) (Salmeron et al., 1997a). However, the source of fiber appears to be important, as cereal fiber but not fruit or vegetable fiber intake has been inversely associated with risk for diabetes in several studies (Salmeron et al., 1997b).

In the *Health Professionals Follow-Up Study* (Hu et al., 2001), the risk of developing diabetes did not decrease with higher total fiber intakes, but a risk reduction of 30 percent was observed in the highest quintile of cereal fiber intake (median 10.2 g per day) compared with the lowest quintile (median intake 1.14 g per day). Again, as in the *Nurses'* cohort, cereal fiber but not fruit or vegetable fiber intake was associated with the protective effect. Similarly, in the *Finnish Mobile Clinic Survey* (Montonen et al., 2003), cereal fiber intake also was associated with a reduced risk of type 2 diabetes. The relative risk between the extreme quartiles of cereal fiber intake was 0.39 ($p = 0.01$). The authors conclude that the similar result for cereal fiber intake and whole-grain intake suggests that the whole-grain association is due to cereal fiber intake.

Possible Confounders With Whole-Grain Intake and Risk of Type 2 Diabetes

Salmeron et al. (1997a; 1997b) found that diets with a high glycemic load and low cereal fiber content were positively associated with the risk of type 2 diabetes mellitus among both adult males and females in the United States. This finding suggests that total glycemic load may be a confounding factor. One study reported a positive relationship between fiber intake and the incidence of diabetes, but this study was retrospective and involved 242 individuals with diagnosed diabetes and 460 individuals without a prior diagnosis. More weight is given to the prospective studies since diet intake is assessed prior to rather than after disease occurrence. It is possible that individuals change their diets after they have been diagnosed with a disease (Marshall et al., 1991).

Whole Grains and Obesity, Weight Gain, Body Mass Index

Several studies have investigated the effect of whole-grain consumption on weight and BMI (often as a secondary analysis in a larger study). For a recent review of these studies see Koh-Banerjee and Rimm, 2003. In the *Nurses' Health Study*, BMI did not vary appreciably across quintiles of whole-grain intake (Liu et al., 1999). In a later report on this same cohort (Liu et al., 2003b), women who consumed more whole grains consistently weighed less than did women who consumed less whole grains ($p < 0.0001$). In the *Iowa Women's Health Study*, whole-grain intake was inversely correlated with body weight and fat distribution (Jacobs et al., 1998). In the *Health Professionals Follow-Up Study* (Koh-Banerjee et al., in press 2004), an increase in whole-grain intake was inversely associated with long-term weight gain (p for trend < 0.0001). A dose-response relation was observed, and for every 40 g increment in whole grains from all foods, weight gain was reduced by 0.49 kg. Independent of whole grains, changes in cereal and fruit fiber inversely predicted weight gain. In the CARDIA study, whole-grain intake was inversely related to BMI at 7-year follow-up of the participants (Pereira et al., 1998). In the *Framingham Offspring Study*, diets rich in whole grains were inversely associated with BMI and with the waist to hip ratio (McKeown et al., 2002). BMI values at the lowest whole-grain intake level averaged 26.9; at the highest whole-grain intake level the average BMI was 26.4 ($p = 0.06$). Weight was 1 to 2 kg higher among those with the lowest intake of whole grain than among those in the upper 20 percent of whole-grain intake.

Since whole grains also are high in fiber, the relationship of fiber intake to BMI is pertinent. In cross-sectional observational studies, fiber has been inversely associated with body weight (Alfieri et al., 1995) and body fat (Miller et al., 1994; Nelson and Tucker, 1996). In a longitudinal study (the CARDIA study), macronutrient and fiber intakes were examined in relation to 10-year weight gain (Ludwig et al., 1999). Fiber had a strong negative association with weight gain, whereas fat had no association. Those in the lowest quintile of fiber intake (< 5 g per 1,000 kcal per day) gained an average of 8 pounds more than those in the highest quintile (> 12 g per 1,000 kcal per day). Fiber was inversely associated with BMI at all levels of fat intake, and the results were not explained by dietary fat intake. In the *Nurses' Health Study* (Liu et al., 1999), women in the highest quintile of dietary fiber intake had a 49 percent lower risk of major weight gain. Over a period of 12 years, those with the greatest increase in intake of dietary fiber gained an average of 1.52 kg less than did those with the smallest increase in intake of dietary fiber ($p \leq = 0.0001$). Again, as shown with whole-grain intake and risk of CHD or diabetes, an important component of the whole grain appears to be the fiber content.

Whole Grains and Cancer

A meta-analysis of 40 studies on gastrointestinal cancers found a 21 to 43 percent lower cancer risk with high intakes of whole grains compared with low intakes

(Jacobs et al., 1998). In a recently reported case-control study on the relationship between frequency of consumption of whole-grain foods and cancer risk in Italy, there was a reduced risk of several cancers. The odds ratios for the highest intake category of whole-grain cereal consumption compared with the lowest category were 0.3 to 0.5 for upper digestive tract and respiratory neoplasms and colon (La Vecchia et al., 2003). A separate case-control study with 952 incident cases of rectal cancer compared with 1,205 population-based controls found that whole-grain intake had a reduced risk for rectal cancer (odds ratio of 0.69) and refined grain intake had a direct association with increased risk of rectal cancer (1.42) (Slattery et al., 2004). In addition, an inverse relationship between cereal and cereal fiber intake and colon cancer incidence was reported in 24 studies, although 7 other studies did not see this effect (Jacobs et al., 1998). The data on dietary fiber intake and colon cancer are inconsistent. Although between-country studies generally show a protective effect of high fiber intake (Boyle et al., 1985), this is not true for within country studies. For example, two large prospective cohort studies in the United States, the *Nurses' Health Study* (Fuchs et al., 1999) and the *Physician's Follow-Up Study* (Giovannucci et al., 1994) do not show a protective effect of fiber intake against colon cancer. Most importantly, the three clinical intervention trials with colon polyp recurrence as an end point also failed to show a protective effect against this surrogate marker for colon cancer (Alberts et al., 2000; Bonithon-Kopp et al., 2000; Schatzkin et al., 2000). There are many reasons for the discrepancy among these different types of studies. Therefore, the overall benefits of whole-grain intake or any of its constituents (such as cereal fiber or fiber per se) and the incidence of colon cancer remain an unresolved issue and further research is needed.

Amount of Whole Grains to Consume

A recent report on the *Health Professionals Follow-Up Study* (Jensen et al., in press 2004) confirms the results of previous individual studies and meta-analyses of servings of whole-grain foods or products with whole-grain content above 25 percent (Anderson et al., 2000; Fraser et al., 1992; Jacobs et al., 1998, 1999; Liu et al., 1999; Steffen et al., 2003). In this report, the beneficial effects for whole-grain consumption are greatest for a daily whole-grain intake above approximately 30 g, regardless of the food source. In the *Iowa Women's Health Study*, the protected quintile for ischemic heart disease was an average of 3.2 whole-grain servings per day (Jacobs et al., 1998). Taken collectively, there are strong and consistent data primarily from prospective cohort studies that whole-grain intake is protective against CHD incidence. The protected quintile of intake appears to be approximately three servings (equivalent to three ounces) of whole grains per day. (See Appendix G-3, "Whole Grains and Chronic Disease Risk.") There is good evidence that whole-grain intake may be protective against type 2 diabetes, and this evidence is supported by measurements of intermediate end points such as blood glucose and insulin concentrations. There is suggestive evidence from a number of secondary analyses that whole-grain intake may protect against weight gain and help with weight maintenance, although the concept that whole-grain intake represents a healthy lifestyle cannot be excluded as a confounder. Children and adolescents should strive to consumer primarily whole grains rather than refined grains.

Question 3: What Are the Relationships Between Milk Product Intake and Health?

Conclusion

Consuming three servings (equivalent to 3 cups) of milk and milk products each day can reduce the risk of low bone mass and contribute important amounts of many nutrients. Furthermore, this amount of milk product consumption may have additional benefits and is not associated with increased body weight. Therefore, the intake of 3 cups of milk products per day is recommended.

Rationale

Overview

The first part of the conclusion is based on the Committee's review of scientific evidence pertaining to nutrient adequacy, improving bone health, and reducing the risk of insulin resistance syndrome. Depending on the study reviewed, milk product intake was assessed by milk (1 serving = 1 cup) and sometimes included other dairy products such as yogurt (1 serving = 1 cup) and cheese (1 serving = 1.5 oz.). The conclusion regarding milk products and weight is supported by the Committee's systematic review of the scientific evidence, including two randomized clinical trials that addressed the question directly; four randomized controlled trials that addressed other questions; two longitudinal, case-control studies of milk group consumption and body weight and fatness; and seven observational studies that reported a secondary analysis of data collected for another purpose.

Many of the health benefits associated with milk consumption may be attributable to the component nutrients, including calcium, potassium, magnesium, vitamin D, and vitamin A. The extent to which components unique to milk products, such as the nature of milk proteins or conjugated linoleic acid (see Question 3 in Section 4, "Fats"), play a role in promoting health is not well understood from the current literature.

Milk Products and Overall Nutrient Adequacy

Milk product consumption has been associated with overall diet quality and adequacy of intake of many nutrients, including calcium, potassium, magnesium, zinc, iron, riboflavin, vitamin A, folate, and vitamin D for children and younger and older adults (Ballow et al., 2000; Barger-Lux et al., 1992; Devine et al., 1996; Foote et al., 2004; Johnson et al., 2002; Weinberg et al., 2004). Increasing the quartile of milk product intake was associated with increased intakes of all micronutrients, except vitamin C, studied among 17,959 participants in the 1994–1996 CSFII (Weinberg et al., 2004). One cross-sectional study in young adults showed that the greatest benefit in intakes of vitamins and minerals was observed in those consuming three or more servings of milk products compared with those consuming two servings or less (Ranganathan et al., in press 2004). Choosing a variety of foods within the dairy food group was strongly associated with improved nutrient adequacy among 4,969 men and 4,800 women participating in the 1994–1996 CSFII (Foote et al., 2004). Milk product and calcium intake in childhood shows a moderate degree of tracking with age (Dwyer et al., 1989; Skinner et al., 2003; Teegarden et al., 1999; Whelton et al., 1997). That is, those who consume milk regularly as children are more likely to do so as adults. Trends in consumption show a decline in milk intake, suggesting that other beverages have displaced milk. For example, in the *Bogalusa Heart Study* (Nicklas et al., 2003), the proportion of 10-year-old children consuming milk declined from 1972 to 1994. During the same period, the children's consumption of sweetened beverages, including soft drinks, sweetened coffee, and fruit-flavored drinks, increased. Fluid milk consumption was negatively related to soft drink consumption in boys and girls (McGartland et al., 2003; Whiting et al., 2001). Soft drink consumption negatively affected bone mineral accrual in the adolescent girls in both studies.

Milk Products and Bone

Because milk products are the major sources of calcium in the diets of Americans, low intake of milk products is associated with low calcium intake. The Institute of Medicine based the Adequate Intakes (AIs) for calcium on maximizing calcium retention and optimizing bone health (IOM, 1997). Studies relating calcium intake and bone health were reviewed by the Institute of Medicine (IOM, 1997) and by Heaney (2000). For dietary guidance, this Committee evaluated studies specifically on milk and other milk products. All 7 of the randomized, controlled trials and 25 of 32 observational studies showed a positive relationship between the intake of milk products and bone mineral content or bone mineral density in 1 or more skeletal sites. (See Appendix G-3.) Bone mineral density is a strong predictor of fracture. Therefore, it is a biomarker for the disease of osteoporosis.

In older adults, the strongest outcome measure for bone health is fracture incidence. Five of the eight observational studies using fracture as an end point found milk product consumption significantly associated with reduced fracture risk. Randomized, controlled trials are less confounded, but they are of insufficient duration to use fracture as an end point.

In studies of all age groups, the magnitude of the effect of milk product consumption on bone is at least as good as that obtained with calcium supplement trials. However, calcium supplements and milk products have not been compared in the same trial to determine whether milk products offer more benefits than does calcium alone. Trials using milk, foods fortified with dairy calcium, or calcium supplements have demonstrated a comparable and important increase in skeletal mass in younger subjects and reduction in loss of skeletal mass in older subjects. In trials using milk or foods fortified with calcium extracted from milk, follow-up showed that the increase in skeletal mass was maintained after the intervention ceased (Bonjour et al., 2001; Ghatge et al., 2001). However, the increase in skeletal mass was not maintained following the interventions that used calcium supplements (Lee et al., 1996; Slemenda et al., 1997). This comparison suggests that skeletal benefits of dairy calcium persist longer than those derived from calcium supplements.

The intake of milk products is especially important to bone health during childhood and adolescence. Using data from 3,251 Caucasian women from NHANES III, low intake (less than one serving of milk per week compared with more than one serving per day) during childhood and adolescence was associated with less hip bone mass in adulthood ($p < 0.04$), and low milk intake during childhood was associated with a twofold greater risk of fracture ($Pp < 0.05$) (Kalkwarf et al., 2003).

This association was not apparent in black women in NHANES III (Opotowsky and Bilezikian, 2003).

Milk Products and Insulin Resistance Syndrome

In a limited number of studies, the consumption of milk products has been related to a decreased risk of insulin resistance syndrome (IRS), otherwise known as syndrome X or the metabolic syndrome. IRS, which is characterized by obesity, insulin resistance, and hyperinsulinemia, leads to glucose intolerance, dyslipidemia, hypertension, and impaired fibrinolytic capacity. Thus, IRS leads to an increased risk for type 2 diabetes and cardiovascular disease (Reaven, 1993). While 22 percent of the U.S. adult population is estimated to have IRS (Ford et al., 2000), currently there are no standard diagnostic criteria and no treatment (Roth et al., 2002). In some studies, higher milk product consumption has been associated with decreased risk of IRS components, including coagulopathy (Mennen et al., 1999), coronary artery disease (Ness et al., 2001), stroke, and hypertension. In a cross-sectional analysis of men and women age 30 to 64, Mennen et al. (2000) demonstrated that greater than 1 serving per day of milk products was associated with a 40 percent lower risk of IRS only in men.

Perhaps the largest study to examine the relationship of milk and IRS is the CARDIA study of 3,157 black and white adults age 18 to 30. In this prospective observational study, milk product consumption was inversely associated with the 10-year cumulative incidence of IRS among those individuals who were overweight (Pereiera, 2002). Each additional serving of milk products was associated with a 21 percent lower odds of IRS (odds ratio, 0.79; 95 percent CI, 0.7 to 0.88). Three or more servings of milk products per day had the most benefit.

Three servings of low-fat milk products were a part of the DASH combination diet (see Section D1 for a description of this diet), which significantly lowered blood pressure (one component of IRS) in adults. In two controlled feeding studies (Appel et al., 1997; Sacks et al., 2001), the DASH diet—which is rich in fruits and vegetables (8 to 10 servings per day) and low-fat milk products (3 servings per day) and reduced in saturated and total fat—lowered systolic blood pressure by 5.5 mmHg and diastolic blood pressure by 3 mmHg in comparison with a typical American diet. The effect of increased fruits and vegetables alone (without the milk product component and other aspects of the DASH diet) was approximately half as large (-2.7 mmHg systolic and -1.9 mmHg diastolic blood pressure). In the PREMIER trial, there was no significant blood pressure difference between two lifestyle interventions, one of which emphasized milk products as well as other features of the DASH diet (Appel et al., 2003). However, participants in this behavioral intervention study did not fully meet nutrient goals of the DASH diet; approximately 60 percent of the participants consumed the amount of milk products prescribed, and only one-third consumed the prescribed amounts of fruits and vegetables.

An analysis of 10 prospective cohort studies relating milk intake at baseline to vascular disease events showed a pooled estimate of relative odds of 0.84 (95 percent CI, 0.78-0.90) for any vascular event and 0.87 (0.74 to 1.03) for ischemic heart disease (Elwood et al., 2004b). Elwood and colleagues (2004a) followed 2,403 men every 5 years for 20 to 24 years, obtaining data on milk intake and incidence of ischemic stroke. The hazard ratio for ischemic stroke in those who consumed 2 or more cups of milk per day, compared with those who did not consume milk, was 0.64 (0.39 to 1.06). The ratio was 0.37 (0.15 to 0.90) in those who had experienced a prior vascular event. Blood pressure was slightly ($p < 0.02$) lower in the men who consumed milk. This emerging role of the relationship between milk product consumption and IRS and its components is provocative. More research is warranted to better understand the role of milk products and their constituents.

Milk Products and Weight Management

Randomized Clinical Trials Addressing the Question—Two randomized clinical trials evaluated the effects of calcium or milk products on body weight and/or body fat loss (Summerbell et al., 1998; Zemel et al., 2004). Both of these relatively small trials found a significant negative relationship between calcium/milk group intake and body weight or fat. Summerbell studied 45 subjects randomized to a control energy-restricted diet, a milk-only diet, or a milk plus one selected food diet. Only 31 subjects finished the trial, and it is not clear that the three dietary treatments were eucaloric. Zemel et al. (2004) randomized 32 subjects to an energy-restricted diet, an energy-restricted diet plus 800 mg supplemental calcium, or a high-milk products (1,200 to 1,300 mg of calcium per day) energy-restricted diet for 24 weeks. Subjects on the high-milk products diet lost 70 percent more weight than those on the standard diet.

Secondary Analyses of Data From Other Randomized Controlled Trials—Four groups evaluated the relationship between milk group or

calcium intake and body weight in randomized controlled trials designed to address other questions. Energy intakes were not controlled in any of these four trials. Barr and coworkers (2000) evaluated the impact of milk group consumption on cardiovascular risk factors and found that subjects in the milk group gained significantly more weight (0.6 kg) than the control group in the 12-week study. However, the net gain was less than anticipated from the increased energy intake from milk products (Barr et al., 2000). To evaluate the relationship between calcium and bone health, Davies et al. (2000) re-evaluated the data from a randomized trial of 216 women who received 1,200 mg of supplemental calcium per day for 3.9 years. Both the calcium-supplemented and control groups lost weight, but the calcium-supplemented group lost significantly ($p < 0.025$) more (0.346 kg per year) weight than the placebo group. Stamler and Dolecek (1997) evaluated the relationship between food intakes and body mass in 6,289 adults participating in the Multiple Risk Factor Intervention Trial (MRFIT). Greater weight loss was associated with greater reductions in medium-fat and high-fat milk products. The overall effect, however, was due to consuming a diet with lower energy density; there was no specific effect of dietary calcium. Also, in the Trials of Hypertension Prevention (TOHP) study, Yamamoto and co-workers (1995) found no effect of supplemental calcium (1 g per day) on BMI in 698 healthy men and women with high-normal diastolic blood pressure (80 to 89 mm Hg) participating in the trial. Energy intakes were not controlled in these four trials.

Longitudinal, Case-Control Studies in Children— Two longitudinal, case-control studies of milk group consumption and body weight and fatness have been done in children (Carruth and Skinner, 2001; Phillips et al., 2003). Carruth and Skinner found that the mean longitudinal calcium intake of preschool children from 24 to 60 months of age was associated with lower body fat at 70 months. However, Phillips et al. (2003) found no evidence that milk group consumption was associated with the BMI z-score or the percentage of body fat in 178 nonobese girls followed from premenarche to 4 years postmenarche.

Observational Studies—Observational studies of the relationship between increased milk group consumption or increased calcium in the diet and body weight or body fat also have been done. The results of those studies are mixed (Buchowski et al. 2002; Davies, et al. 2000; Drapeau et al., 2004; Jacqmain et al., 2003; Lin et al., 2000; Lovejoy et al., 2001; Melanson et al., 2003; Pereira et al., 2002). None of the observational studies were designed with the intention of studying the relationship between milk group intake or calcium consumption and either body weight or composition. Instead, the papers report a secondary analysis of data collected for another research question. Heterogeneity in methodologies used to measure body composition and dietary intake, along with differences in the number and type of variables used as covariates and the manner in which calcium intake is expressed (i.e., energy-adjusted or protein-adjusted), may account for the divergent results.

Recommendations from Other Groups— A recommendation of three servings of milk products per day (see Table D1-13) is consistent with recommendations from other authoritative groups (American Academy of Pediatrics, 2001; American Heart Association, 2004; National Medical Association, 2004). Mean intake of milk products is much lower than this, and only about 28 percent of men and 15 percent of women consume two servings per day.

Milk Products Summary—Taken collectively, there is strong and consistent evidence that the intake of milk products is protective against osteoporosis and limited evidence that milk product intake protects against IRS. The protected quintile of intake appears to be approximately three servings of milk or milk products per day. The possible reduction of the incidence of IRS with higher milk product consumption may be partially or mostly related to the calcium content of milk products.

None of the studies show that milk group consumption is associated with an increase in body weight. Since adults and children benefit from including milk products in the amounts suggested in the revised USDA food intake pattern—both for bone health and for lowering the risk of several diseases—milk products are recommended as part of the overall dietary pattern. There is no evidence that milk products should be avoided because of concerns that these foods are fattening. Because of the lack of large-scale, randomized trials or controlled feeding studies designed explicitly to test the effect of milk group intake or calcium consumption on body weight, and the limitations of the studies reported above, at this time there is insufficient evidence on which to base a more definitive statement regarding the intake of milk products and management of body weight.

Summary

The main message from these reviews is that an increased intake of fruits and vegetables (2½ to 6½ cups; equal to 5 to 13 servings depending on caloric needs) and the consumption of approximately 3 ounces of whole grains daily promote health and reduce the risk of chronic diseases. In addition, the daily consumption of approximately 3 cups of nonfat or low-fat milk or the equivalent from other milk products can reduce the risk of low bone mass. All these foods make important nutrient contributions. There is no evidence that the recommended amounts of milk products increase body weight. The DASH diet, which is consistent with the recommendations made here, has been demonstrated to have beneficial effects on health. (See Section D1.)

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Section 7: Fluids and Electrolytes

This section addresses three major questions related to the intake of fluid and the electrolytes sodium and potassium.

1. What amount of fluid is recommended for health?
2. What are the effects of salt (sodium chloride) intake on health?
3. What are the effects of potassium intake on health?

The Committee placed a strong focus on sodium and potassium because of the substantial body of research linking these electrolytes to levels of blood pressure. Part B, "Introduction," provides background information on the problem of elevated blood pressure and its control. That information can help the reader appreciate the importance of blood pressure as a modifiable risk factor for cardiovascular and kidney diseases and of dietary factors that can lower and possibly control blood pressure.

The conclusions in this section are largely based on evidence from an extensive, systematic, and very recent review of the scientific literature conducted by an expert panel for the Institute of Medicine (IOM) (IOM, 2004). For topics not covered in the IOM report, we conducted literature searches. The search strategies used to find the scientific evidence related to each of these questions appears in Part C, Methodology.

Question 1: What Amount of Fluid Is Recommended for Health?

Conclusion

The combination of thirst and usual drinking behavior, especially the consumption of fluids with meals, is sufficient to maintain normal hydration. Healthy individuals who have routine access to fluids and who are not exposed to heat stress consume adequate water to meet their needs. Purposeful drinking is warranted for individuals who are exposed to heat stress or who perform sustained vigorous activity.

Rationale

Recommendations for water are made to prevent the deleterious, primarily acute, effects of dehydration. These effects include impaired cognitive function and motor control. Although a low intake of water has been associated with some chronic diseases, this evidence is insufficient to establish recommendations for water consumption.

The primary indicator of hydration status is plasma or serum osmolality. Appendix G-1 from the recent IOM report (IOM, 2004) provides the serum osmolality by decile of total water intake in the third *National Health and Nutrition Examination Survey* (NHANES III). Serum osmolality concentrations were essentially identical (the maximum range between the lowest and highest decile was only 3 mOsmol/kg). These data indicate that persons in the lowest and highest deciles of total water intake were neither systematically dehydrated nor hyperhydrated. Importantly, this pattern of findings also was evident in men and women age 71 and older.

Thirst, which is the desire to drink by both physiological and behavioral cues, may be triggered by a decrease in blood volume or severe dehydration. Over the course of a few hours, body water deficits can occur. However, thirst mechanisms come into play over the ensuing 24 hours to trigger replacement of fluids lost (Johnson, 1964). Such replacement is enhanced by consuming beverages at meals and in other social situations (Engell, 1995; Szlyk, 1990).

Total water intake includes drinking water, water in beverages, and water contained in food. Because normal hydration can be maintained over a wide range of water intakes, the Adequate Intake (AI) for total water was set based on the median total water intake from U.S. survey data (IOM, 2004). The AI for total water intake for young men and women (age 19 to 30 years) is 3.7 L and 2.7 L per day, respectively. In NHANES III, fluids (drinking water and beverages) provided 3.0 L (101 fluid ounces; ~13 cups) and 2.2 L (74 fluid ounces; ~9 cups) per day for men and women age 19 to 30, representing approximately 81 percent of total water intake. Water contained in food provided about 19 percent of total water intake.

The AI should not be interpreted as a specific requirement or recommended intake. Individual water requirements can vary greatly, even on a day-to-day basis, primarily because of differences in physical activity and environmental conditions but also because of differences in diet. A total water intake above the AI often is required by those individuals who are physically active or who are exposed to heat stress.

In individuals who are neither physically active nor exposed to heat stress, daily consumption below the AI can be sufficient to maintain normal hydration. Dietary factors also influence water requirements because total water consumption must be sufficient to excrete metabolites of protein and organic compounds, as well as excess electrolytes.

Because healthy individuals have considerable ability to excrete excess water and thereby maintain water balance, the IOM did not set a Tolerable Upper Intake Level (UL) for water. However, acute water toxicity can occur following the rapid consumption of large quantities of fluids that greatly exceed the kidney's maximal excretion rate of approximately 0.7 to 1.0 L per hour.

Question 2: What Are the Effects of Salt (Sodium Chloride) Intake on Health?

Conclusion

The relationship between salt (sodium chloride) intake and blood pressure is direct and progressive without an apparent threshold. Hence, individuals should reduce their salt intake as much as possible. In view of the currently high levels of salt intake, a daily sodium intake of less than 2,300 mg is recommended. Many persons will benefit from further reductions in salt intake, including hypertensive individuals, blacks, and middle-aged and older adults. Individuals should concurrently increase their consumption of potassium because a diet rich in potassium blunts the effects of salt on blood pressure.

Rationale

A recent report from the IOM (IOM, 2004) provides the basis for a recommended daily sodium intake (an AI) of 1,500 mg and a UL of 2,300 mg for adults.[1,2] These recommendations are based on an extensive examination of the scientific literature by an expert IOM (IOM) panel. The primary basis for setting the AI was to ensure overall nutrient adequacy, not to prevent chronic disease. In contrast, the UL was set because of the direct relationship of salt intake with blood pressure.

Review of the Evidence

Studies of the Relationship of Sodium Intake and Blood Pressure—The relationship between sodium intake and blood pressure is direct and progressive. In addition to observational studies, supportive evidence comes from more than 50 clinical trials and meta-analyses (see IOM, 2004, Tables 6-12, 6-13, 6-15, 6-16, and Appendix I). The best available dose-response evidence comes from individual trials that specifically examined this relationship (i.e., randomized trials that tested the effects of three or more levels of sodium intake on blood pressure). In these dose-response studies, the lowest level of sodium intake ranged from approximately 230 to 1,500 mg of sodium per day, while the highest level ranged from approximately 3,200 to over 34,000 mg of sodium per day. The largest and most rigorous of these trials documented statistically significant, progressive dose-response relationships (Johnson et al., 2001; MacGregor et al., 1989; Sacks et al., 2001). Most important, there was no evidence of a threshold; that is, the direct relationships were evident throughout the range of salt intake.

The trial by Johnson et al. (2001) tested the effects of 5 levels of sodium intake (lowest to highest: 920 mg per day to 7,800 mg per day) in 40 older-aged persons (nonhypertensives, persons with isolated systolic hypertension, persons with combined systolic-diastolic hypertension). The trial by MacGregor et al. (1989) tested the effects of 3 levels of sodium intake (1,100; 2,300; and 4,600 mg of sodium per day) in 20 hypertensive adults. The largest of the dose-response trials, the *Dietary Approaches To Stop Hypertension* (DASH) *-Sodium* trial, tested the effects of three different sodium intakes separately in two distinct diets—the DASH diet and a control diet. The DASH diet is described in detail in Section D1 and in Table D1-18. In brief, the DASH diet is rich in fruits, vegetables, and low-fat dairy products and reduced in total fat, saturated fat, and cholesterol. The control diet is typical of what many Americans eat, that is, relatively high in total and saturated fats and low in fruits, vegetables, and low-fat milk products. Mean achieved levels of sodium intake, as reflected by 24-hour urinary sodium excretion, corresponded to approximate intakes of 1,500, 2,500, and 3,300 mg in the lower, intermediate, and higher doses, respectively.

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[1] Previous recommendations from authoritative sources have recommended consuming less than 2,400 mg of sodium rather than 2,300 mg. The limit of 2,400 mg is equivalent to 6 g of sodium chloride, whereas the limit of 2,300 mg corresponds to 100 mmol of sodium. Previous standards had been based on milligrams of sodium chloride rather than millimoles of sodium.

[2] In view of the form of published data and nutrition labeling, which typically provide milligrams of sodium rather than milligrams of salt, this section will present recommendations in milligrams of sodium.

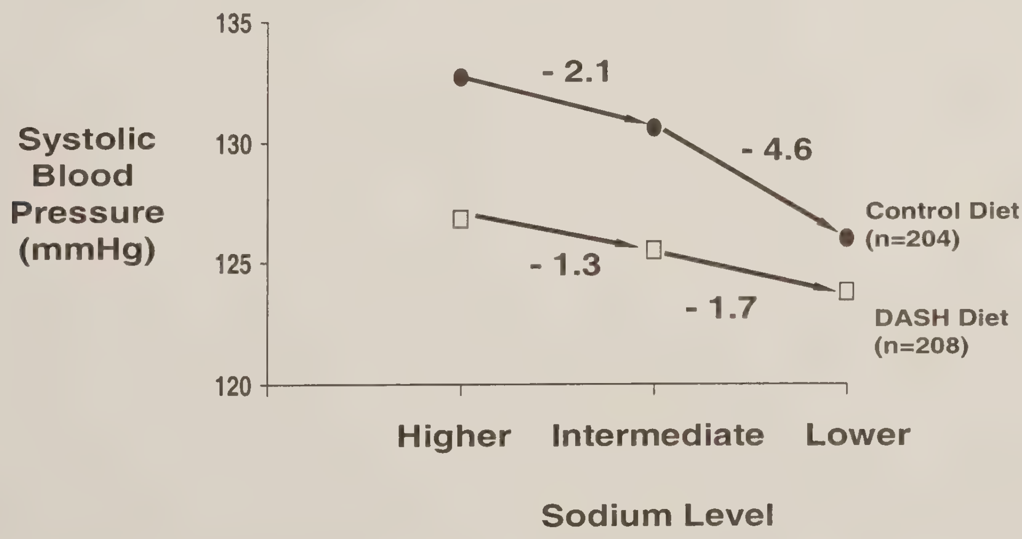
Of the 3 dose-response trials, the DASH-Sodium trial enrolled the largest and most diverse population; 41 percent were hypertensive, 40 percent were white, and 57 percent were black. However, the DASH-Sodium trial had the narrowest range of sodium intake; approximately half of the U.S. population consumes sodium in excess of the highest level tested in this trial (Rose et al., 1988).

The main results of the DASH-Sodium trial are displayed in Figure D7-1. The blood pressure response to sodium reduction was nonlinear. Specifically, reducing sodium intake by approximately 920 mg per day caused a greater lowering of blood pressure when the initial sodium intake was at the intermediate level than when it was at the higher intake; this pattern of results was especially evident on the control diet. Results from the INTERSALT observational study (Rose et al., 1988) and from the Johnson trial likewise suggest that the blood pressure response to changes in sodium intake is steeper below 2,300 mg per day than above 2,300 mg per day.

In protocol-specified subgroup analyses of the DASH-Sodium trial (Vollmer et al., 2001), a reduced-sodium intake significantly lowered blood pressure in each of the major subgroups on the control diet. On the control diet, reduced-sodium intake led to greater systolic blood pressure reduction among hypertensive individuals, blacks, and persons age 45 years and older compared to their counterparts. Net systolic/diastolic blood pressure reductions associated with reducing salt from the higher to the lower level in hypertensives and nonhypertensives were 8.3/4.4 and 5.6/2.8 mmHg, respectively. On the DASH diet, a qualitatively similar pattern was evident, but the extent of blood pressure reduction was less; net systolic/diastolic blood pressure reductions associated with reducing salt from the higher to the lower level in hypertensives and nonhypertensives were 4.9/2.5 and 1.7/1.1 mmHg, respectively. In each subgroup, the lowest blood pressure was observed on the DASH diet with the lower sodium level.

In subsequent post-hoc analyses, Bray et al. (2004) presented results in joint subgroups (age and hypertension status, race/ethnicity and hypertension status, and sex and race/ethnicity). In the control diet, sodium reduction significantly lowered systolic blood pressure in each subgroup. In the DASH diet, many but not all blood pressure changes associated with sodium reduction were statistically significant in the subgroups. In all subgroups, the DASH diet significantly lowered blood pressure at the higher sodium level; however, at the lower sodium level, several blood pressure reductions did not achieve statistical significance. Overall, the general pattern of results in subgroup analyses was similar to that of the main results. Deviations between main results and subgroup analyses, especially post-hoc analyses, should be interpreted cautiously because of reduced sample size and hence the potential for failing to detect significant associations.

Figure D7-1. Dose-response relationship between systolic blood pressure and sodium intake in two diets: Main results from the DASH sodium trial (Sacks FM et al., 2001)



The control diet represents the typical American diet. DASH diet emphasizes fruits, vegetables, and low-fat dairy foods; includes whole grains, poultry, fish, and nuts; and is reduced in fats, red meat, sweets, and sugar-containing beverages. The three sodium levels are defined as higher (3,450 mg/d), intermediate (2,300 mg/d), and lower (1,150 mg/d).

The control diet, in which the blood pressure effect of sodium reduction was the largest, is closer to what most Americans currently eat than is the DASH diet. For instance, in the United States less than 10 percent of adult men and 1 percent of women consume 4.7 g per day of potassium (the potassium goal of the DASH diet), and less than 25 percent of adult men and less than 5 percent of adult women have a daily calcium intake from foods of 1,240 mg per day (the calcium goal of the DASH diet) (IOM, 2004). The low-saturated fat and total-fat contents of the DASH diet (goals of 6 percent and 27 percent kcal, respectively) are likewise uncommon in the U.S. population. These observations, coupled with the consistency of the findings across subgroups, support recommendations to concurrently reduce sodium intake and consume the DASH diet. Although the duration of each feeding period lasted only one month, it is reasonable to speculate that adherence to the combination of the DASH diet and reduced sodium intake might help blunt the well-documented rise in blood pressure that occurs with age, especially because reductions in systolic blood pressure were greater in the older than younger participants.

As documented above (see IOM, 2004, Tables 6-13 and 6-15), the effects of sodium on blood pressure are large and clinically relevant in hypertensive individuals not on medication. Sodium reduction also lowers blood pressure in the presence of antihypertensive drug therapy (Appel et al., 2001). Although the effects of sodium intake on blood pressure are smaller in nonhypertensive individuals, the potential benefits of sodium reduction on blood pressure have substantial public health relevance. Stamler et al. (1989) estimated that a 3 mmHg reduction in systolic blood pressure could lead to an 8 percent reduction in stroke mortality and a 5 percent reduction in mortality from coronary heart disease. In observational studies, a reduced salt intake (as manifest by 24-hour urinary sodium excretion) is also associated with a blunted age-related rise in blood pressure (Rose et al., 1988).

Sodium reduction can also prevent incident hypertension. To date, three trials have explored the effects of a reduced sodium intake as a means to prevent hypertension (*Hypertension Prevention Trial* [HPT], *Trial of Hypertension Prevention Phase I* [TOHP1], and *Phase II* [TOHP2 Collaborative Research Group, 1997]). HPT and TOHP1 were pilot studies that were conducted to inform the design of TOHP2. Each study was a controlled trial in which a behavioral intervention focused exclusively on reducing sodium intake. HPT and TOHP2, also included groups that simultaneously implemented other interventions: increased potassium intake in HPT and weight loss in TOHP2 (1997). Net reductions in urinary sodium excretion on the sodium reduction arm were modest in the three studies, ranging from the equivalent of 300 mg to ~1,300 mg of sodium per day, at the end of follow-up. In this setting, a reduced sodium intervention that did not include any other lifestyle change led to a decreased relative risk of incident hypertension (range 0.69 to 0.82).

Results from TOHP2 are especially relevant because this trial was designed and adequately powered to test the effects of a reduced dietary sodium intervention as a means to prevent hypertension. TOHP2 was a randomized, controlled 2 x 2 factorial trial that tested the effects of 3 lifestyle interventions (sodium reduction, weight loss, or combined weight loss and sodium reduction) on blood pressure and incident hypertension over 3 to 4 years of follow-up in overweight individuals aged 30 to 54 years with an initial diastolic blood pressure of 83 to 89 mm Hg and a systolic blood pressure < 140 mm Hg. At 6 months, the height of intervention adherence, the incidence of hypertension was lowest in the combined group (2.7 percent), intermediate in the weight loss only (4.2 percent) and sodium reduction only (4.5 percent) groups, and highest in the control group (7.3 percent). At 18 months, the pattern persisted. By the end of follow-up, the incidence of hypertension was 18 to 22 percent less in each lifestyle group ($p < 0.05$ compared to control) but not different from each other. Results of this trial indicate that lifestyle interventions can prevent hypertension over the long term. Also, the pattern of incident hypertension at 6 and 18 months suggests that the effects of weight loss and reduced sodium intake, under optimal conditions of adherence, may be additive.

Relying on behavioral interventions to reduce dietary intake of sodium presents a major barrier to the achievement of greater reductions in blood pressure and to a reduction in the associated CVD complications. In contrast to the short-term (3-day) feeding trials that could achieve contrasts in sodium intake of nearly 34,300 mg per day (Luft et al., 1979), the maximum contrast in the primary prevention trials was 1,300 mg per day in TOHP1. The average contrast in long-term trials lasting 6 months was only 800 mg per day (Hooper et al., 2002). The limited contrast in sodium intake in these trials reflects the difficulties of sustaining behavior change when the most common source of sodium, namely processed foods, accounts for more than 75 percent of total sodium intake and when discretionary salt intake accounts for only 11 percent (5 percent added during cooking and 6 percent added at the table) (Mattes, 1997). The sodium that

occurs naturally in foods accounts for the remainder (approximately 10 percent).

Salt Sensitivity—Evidence from a variety of studies, including observational studies and clinical trials, has demonstrated heterogeneity in the blood pressure responses to sodium intake. Those individuals with the greatest reductions in blood pressure in response to decreased sodium intake are termed ***salt sensitive***. Despite the use of the terms ***salt sensitive*** and ***salt resistant*** to classify individuals in research studies, the change in blood pressure in response to a change in salt intake is not binary. Rather, the reduction in blood pressure from a reduced sodium intake has a continuous distribution across individuals. Also, there are no standardized diagnostic criteria and tests. Despite these limitations, it is possible to make some general observations.

Salt sensitivity is modifiable. The rise in blood pressure from increased salt intake is blunted in the setting of a high potassium intake (4.7 g of supplemental potassium per day in one trial [Morris et al., 1999]; 6.7 g per day in another trial [Schmidlin et al., 1999]). The rise in blood pressure from increased salt intake was also blunted in the setting of the DASH diet, which is rich in potassium (4.6 g of potassium per day) as well as other minerals (Table D7-1) (Bray et al., 2004; Karanja et al., 1999; Sacks et al., 2001; Vollmer et al., 2001); nonetheless, a dose-response relationship between sodium intake and blood pressure persisted.

Individuals with hypertension, diabetes, and chronic kidney disease, as well as middle- and older-aged persons and blacks tend to be more salt sensitive than their counterparts. Genetic factors also influence the blood pressure response to salt. Each of the 14 identified genes that affect blood pressure affects renal salt handing. Such evidence provides indirect support of an etiologic role of sodium in blood pressure homeostasis (Lifton, 2002).

Relationships Between Salt Intake and Health Outcomes Other Than Blood Pressure—As documented by the IOM (IOM, 2004), an increased sodium intake might have adverse effects on additional health outcomes. These include clinical cardiovascular outcomes (i.e., stroke and coronary heart disease), subclinical cardiovascular outcomes (i.e., left ventricular mass), and noncardiovascular outcomes (e.g., urinary calcium excretion, osteoporosis, and gastric cancer). Cross-sectional studies consistently document an association between urinary sodium excretion and left ventricular mass, but only one small controlled trial assessed the effects of sodium reduction on this endpoint. Numerous trials document that a reduced sodium intake lowers urinary calcium excretion (Table 6-19; IOM, 2004), but urinary calcium excretion, by itself, is not a well-accepted surrogate marker for bone mineral density or dietary induced osteoporosis. Evidence that links sodium intake with gastric cancer is reasonably strong but still insufficient to establish a UL for sodium. No trial has tested the effects of sodium reduction as a means to prevent cardiovascular disease (CVD). However, the most rigorous observational studies (He and MacGregor, 1999; Tuomilehto et al., 2001; see IOM, 2004, Table 6-17) have documented a direct relationship of sodium intake with CVD.

Salt Taste Preferences—At birth, there is no indication that salty substances are distinguishable or preferred (Beauchamp et al., 1986). Preference for the salty taste appears at about four months postnatal (Beauchamp et al., 1994; Beauchamp et al., 1986; Harris and Booth, 1987). Limited evidence suggests that infants' and children's salt preference is shaped by their experience with salt in foods (Beauchamp, 1990; Stein et al., 1996).

Adult salt preferences can be influenced by dietary exposure. Studies have demonstrated that reducing one's dietary sodium intake can decrease one's preference for salty foods and increase acceptance of foods with reduced sodium content (Bertino et al., 1982). Several studies document a temporary increased preference for salt over the initial few weeks when sodium intake is reduced (Bertino et al., 1981; McCance, 1936; Teow et al., 1985–1986; Yensen, 1959). Subsequently, a shift in preference occurs such that by 8 to 12 weeks individuals prefer less salty foods (Bertino et al., 1982; Mattes et al., 1991; Mattes, 1997). This phenomenon also has been demonstrated in long-term studies lasting one year or more (Blais et al., 1986).

On average, the natural salt content of food accounts for only 10 percent of total intake, while discretionary salt use (i.e., table and cooking salt) provides another 5 to 10 percent of total intake. The remaining 75 percent is derived from salt added by manufacturers (James, 2000; Mattes 1991, 1997). When total intake of salt is decreased, discretionary salt use is fairly stable, even when available *ad libitum* (Mattes, 1997). Therefore, any program for reducing the salt consumption of a population should concentrate primarily on a reduction in the salt used during food processing (James, 2000) and on changes in food selection (e.g., more fresh, less-processed items, less sodium-dense foods) and preparation (Mattes, 1997). Previous guidelines have

Table D7-1. Trials That Assess the Main and Interactive Effects of Salt and Potassium on Blood Pressure

Citation	Design	Population	Sodium Levels Tested	Potassium Levels Tested	Duration	Main Effects of Sodium	Main Effects of Potassium	Interactive Effects	Interpretation
Sacks et al., 2001	Crossover trial of three sodium levels, parallel trial of 2 diets	412 adults, 59% women, 57% AA, 135/86 mmHg	50 (L), 100 (I), 150 (H) mmol/day	1700 mg/d in control diet, 4700 mg/day in DASH diet	30 days	SBP: -6.7 mmHg (H to L) in control diet, -3.0 mmHg in DASH diet; DBP: -3.5 mmHg (H to L) in control diet, -1.6 mmHg in DASH diet	SBP (DASH diet net of control): -5.9 mmHg at H, -2.2 mmHg at L; DBP (DASH diet net of control): -2.9 mmHg at H, -1.0 mmHg at L	Subadditive effect of sodium reduction and DASH diet (*p*<0.001)	The DASH diet (rich in potassium) blunts but does not eliminate the effects of increased sodium on blood pressure. A low sodium intake blunts the effects of the control diet (low in potassium) on blood pressure.
Morris et al., 1999	Parallel, sequential phases; baseline (I) with low K+Na, then 'Na loading' low K and high Na, then 'K loading'	38 men, 63% AA, <140/<90 mmHg	15 mmol/day (basal diet), then 250 mmol/d (high salt)	30 mmol/day (basal diet), then 70 mmol (A), 70 mmol (B), 120 mmol (C), placebo (D)	6 wks total (2 wk basal, 1 wk Na loading, 3 wks with K loading	Pre-Post Na loading: SBP: +8.8 mmHg in blacks (basal to high salt), +2.9 mmHg in whites (basal to high salt); +DBP: 5.6 mmHg in blacks (basal to high salt), +1.4 mmHg in whites (basal to high salt)	Pre-Post K loading: SBP: -4.9 mmHg in blacks (basal to A or B tx), -2.5 mmHg in whites (basal to A or B tx); DBP: -3.3 mmHg in blacks (basal to A or B tx), -1.9 mmHg in whites (basal to A or B tx)	Supplementing dietary potassium at 70 mmol/d attenuated moderate salt sensitivity in both blacks and whites (*p*<0.01) and at 120 mmol/d abolished salt sensitivity and suppressed the frequency and severity of salt sensitivity in blacks (n=5) to levels similar to those observed in whites.	Effects of sodium and potassium based on pre-post BP change, not net of placebo. K appears to blunt the rise in blood pressure from sodium and do so in a dose-dependent fashion in blacks.

Table D7-1 (cont.). Trials That Assess the Main and Interactive Effects of Salt and Potassium on Blood Pressure

Citation	Design	Population	Sodium Levels Tested	Potassium Levels Tested	Duration	Main Effects of Sodium	Main Effects of Potassium	Interactive Effects	Interpretation
Skrabel et al., 1981	2 x 2 factorial	20 men, 21–25, all non-hypertensive, 125/73.1 mmHg	50, 200 mmol	80, 200 mmol	2 wks	SBP: -2.7, DBP -3.0, both NS	SBP: -1.7, DBP: -4.5, both NS	SBP: -2.3, DBP: -3.5, both NS	Small trial, all BP change NS
Chalmers et al., 1986	2 x 2 factorial	212 adults with hypertension, DBP: 90-100 mmHg	~80, ~150 based on 24 hr urines	~70, ~90 based on 24 hr urines	12 wks	SBP: -3.9, DBP: -3.1, both sign	SBP: -5.1, DBP: -4.2, both sign	SBP: -4.2, DBP: -2.6, both sign; no formal test but BP effects of increased K and reduced Na appear subadditive	Increased potassium or reduced sodium, alone or together, reduce blood pressure to the same extent.

focused on decreasing the intake of foods and beverages high in salt (HHS 1985, 1990, 1995, 2000) because of their large contribution of salt intake in the diet.

Recommendations for Salt (Sodium Chloride) Intake—The IOM set the AI for sodium for adults at 1,500 mg per day to ensure that the overall diet provides sufficient amounts of other nutrients and to cover sodium sweat losses in unacclimatized individuals who are exposed to high temperatures or who are moderately physically active (IOM, 2004). This amount of sodium does not apply to highly active individuals, such as endurance athletes and certain workers (e.g., foundry workers) who lose large amounts of sweat on a daily basis and thus require a higher sodium intake.

The IOM set the UL at 2,300 mg of sodium per day (IOM, 2004). In dose-response trials, this level of sodium intake commonly was the next tested level above the AI. The UL of 2,300 mg of sodium daily is not a recommended intake. There is no benefit to consuming sodium in an amount that exceeds the AI. For members of groups that are most sensitive to the blood pressure effects of increased salt intake (that is, middle- and older-aged persons, blacks, and individuals with hypertension, diabetes, or chronic kidney disease), it is advisable to consume an amount of sodium that is less than the UL. These groups also have higher levels of blood pressure.

Positions Taken by Other Policymaking Groups—Numerous policymaking organizations have recommended a reduced salt intake as a means to lower blood pressure in the general population. In the United States, the National High Blood Pressure Education Program set a sodium intake goal of 100 mmol (2,300 mg) per day as a means to prevent hypertension in nonhypertensive individuals (Whelton et al., 2002) and as first line and adjuvant therapy in hypertensive individuals (Chobanian et al., 2003). The American Heart Association set an intake of 6 g of salt (2,400 mg of sodium) per day as a recommended upper limit for healthy Americans. In Great Britain, the Scientific Advisory Committee on Nutrition in 2003 conducted an independent review of available evidence and also set an upper limit of 6 g of salt (2,400 mg of sodium) per day. Recently published Canadian recommendations for the prevention and treatment of hypertension are to restrict salt intake to 65 mmol to 100 mmol (1,500 mg to 2,300 mg) per day in hypertensive individuals and to 100 mmol (2,300 mg) per day in normotensive individuals at risk for becoming hypertensive (Touyz et al., 2004). Note that in the United States, 90 percent of adults will develop hypertension (Vasan et al., 2002).

In its report, *Diet, Nutrition and the Prevention of Chronic Diseases* (2003), the World Health Organization set an upper limit of 70 mmol (1,600 mg) of sodium per day as a means to lower blood pressure.

Sodium Intakes

According to data from NHANES III (IOM, 2004), the median intakes of sodium among adult men and women age 31 to 50 are 4,300 mg and 2,900 mg of sodium per day, respectively. One quarter of adult men exceed 5,200 mg of sodium per day, and one quarter of women exceed 3,500 mg per day. Approximately 95 percent of adult men and 75 percent of adult women exceed the UL of 2,300 mg of sodium per day, and 100 percent exceed the AI of 1,500 mg of sodium per day. On average, blacks and nonblacks consume similar amounts of sodium. The reported sodium intakes probably are underestimates of total sodium intake because the NHANES III did not ask about discretionary salt intake.

Question 3: What Are the Effects of Potassium Intake on Health?

Conclusion

Diets rich in potassium can lower blood pressure and lessen the adverse effects of salt on blood pressure, may reduce the risk of developing kidney stones, and possibly decrease bone loss. In view of the health benefits of potassium and its relatively low intake by the general population, a daily potassium intake of at least 4,700 mg is recommended. Blacks are especially likely to benefit from an increased intake of potassium.

Rationale

Review of the Evidence

Effect of Potassium on Blood Pressure and Salt Sensitivity—Supportive evidence for the conclusion that an increased potassium intake lowers blood pressure appears in the IOM report (IOM, 2004), as follows:

- Table 5-2 covering 17 observational studies
- Tables 5-3 through 5-5 covering 36 clinical trials

Most trials tested pill supplements, typically in the form of potassium chloride (IOM, 2004, Tables 5-4 and 5-5). Three meta-analyses of these trials document that, on average, increased potassium intake lowers blood pressure in nonhypertensive and hypertensive

individuals (Cappuccio and MacGregor, 1991; Geleijnse et al., 2003; Whelton et al., 1997). In the meta-analysis by Whelton et al. (1997), average net systolic/diastolic blood pressure reductions from a net increase in urinary potassium excretion of 2 g per day (50 mmol per day) were 4.4/2.5 mmHg among hypertensive individuals and 1.8/1.0 mmHg among nonhypertensive individuals. No dose-response trial tested the effects of more than two levels of potassium intake on blood pressure.

Relatively few trials tested the effects of potassium as provided in foods (Table 5-3, IOM, 2004). The potassium in fruits and vegetables is accompanied by bicarbonate precursors rather than chloride. In the initial DASH trial, a diet rich in fruit and vegetables (and therefore rich in potassium) lowered blood pressure (Appel et al., 1997). Another trial documented that increased fruit and vegetable consumption can significantly lower blood pressure (John et al., 2002), but that trial did not report the potassium intake of participants on the fruit and vegetable intervention.

Because virtually all trials used potassium chloride supplements while observational studies assessed dietary potassium intake from foods (paired with nonchloride anions), the effect of potassium on blood pressure appears to result from potassium rather than its conjugate anion. No single trial tested the effects of three or more levels of potassium intake on blood pressure; hence, the dose-response relationship is unclear. Still, blood pressure reductions from supplemental potassium occurred when baseline intake was low (e.g., 1.3 to 1.4 g of potassium per day in Brancati et al., 1996) and when baseline intake was much higher (> 3.1 g of potassium per day in Naismith and Braschi [2003]).

Evidence from the observational studies and clinical trials has demonstrated heterogeneity in the blood pressure responses to potassium intake. Blacks and hypertensive individuals are more sensitive to the effects of potassium than their nonblack and normotensive counterparts, respectively. Dietary salt intake also modifies the effects of potassium on blood pressure. Specifically, the effects of potassium on blood pressure are greater when salt intake is high than when salt intake is low (see Table D7-1).

Some trials have assessed the effects of increased potassium intake on salt sensitivity, that is, the pressor response to increased salt intake. Study populations included nonhypertensive predominantly black individuals (Morris et al., 1999; Schmidlin et al., 1999) and hypertensive individuals (Morgan et al., 1984). These trials are consistent in documenting that potassium blunts the pressor (blood-pressure raising) effects of salt. One dose-response trial documented that increasing potassium intake to 4.7 g per day reduced salt sensitivity in nonhypertensive blacks (Morris et al., 1999). In aggregate, these trials highlight the potential benefits of increasing potassium intake in blacks, a group of individuals with a high prevalence of hypertension and of blood pressure-related cardiovascular-renal disease.

To date, no trial has tested the effects of increased potassium intake on blood pressure-related clinical outcomes. However, observational studies suggest that increased potassium intake may prevent stroke and perhaps coronary artery disease (see Table 5-6, IOM, 2004).

Effect of Potassium in Preventing Bone Loss and Kidney Stones—A diet rich in potassium from fruits and vegetables favorably affects acid-base metabolism because these foods also are rich in precursors of bicarbonate (Sebastian, et al., 1994, 2002). Acting as a buffer, the bicarbonate-yielding organic anions found in fruits and vegetables neutralize acids generated from meats and other high-protein foods. Inadequate intake of bicarbonate precursors creates excess acid in the blood resulting in bone buffer titration and demineralization of the bone. Increased bone breakdown and calcium-containing kidney stones are adverse consequences of excess acid derived from the diet. Therefore, diets rich in potassium with its bicarbonate precursors might help prevent kidney stones and bone loss.

To date, two observational studies have documented that high intakes of potassium (median of 4.0 g per day in men and 4.7 g per day in women) are associated with a reduced risk of incident kidney stones (Curhan et al., 1993, 1997). In a third observational study conducted in Finland, the relationship was statistically nonsignificant, perhaps because of the much higher usual levels of potassium consumed in this population (Hirvonen et al., 1999). In addition, one trial (Barcelo et al., 1993) documented that approximately 3.6 to 4.7 g of supplemental potassium citrate reduced the risk of recurrent kidney stones. The potassium added to processed foods and the potassium in supplements typically has chloride as the conjugate anion. Since chloride cannot neutralize excess acid in the body, this form of potassium is not expected to help prevent kidney stones or bone loss.

Observational studies, including both cross-sectional studies and longitudinal studies, suggest that increased

potassium intake is associated with increased bone mineral density (see IOM, 2004, Table 5-7). Trials also have documented that supplemental potassium bicarbonate can reduce bone breakdown and increase bone formation (Sebastian et al., 1994). However, no trial has tested the effect of increased potassium or diets rich in potassium on bone mineral density or on clinical outcomes related to osteoporosis.

Recommendations for Potassium Intake

The IOM set the AI for potassium for adults at 4,700 mg per day. This level of intake should maintain lower blood pressure levels, mitigate the adverse effects of salt on blood pressure, reduce the risk of developing kidney stones, and possibly decrease bone loss. At present, dietary intake of potassium by all groups in the United States is considerably lower than 4,700 mg per day. In recent surveys, the median intake of potassium by adults in the United States was approximately 2,900 to 3,200 mg per day in men and 2;100 to 2,300 mg per day in women. On average, blacks consume less potassium than nonblacks. Among men, age 31 to 50 years, median potassium intake was approximately 2,600 mg in blacks and 3,300 mg in nonblacks. Corresponding figures in women were 1,900 mg and 2,400 mg, respectively (see Table D7-1). Because blacks have a relatively low intake of potassium and a high prevalence of elevated blood pressure and salt sensitivity, this subgroup of the population would especially benefit from an increased intake of potassium.

In the generally healthy population with normal kidney function, a potassium intake from foods that exceeds 4.7 g per day poses no potential for increased risk because excess potassium is readily excreted in the urine. Hence, the IOM did not set a UL for potassium (IOM, 2004). However, a potassium intake below 4.7 g per day is indicated for individuals whose urinary potassium excretion is impaired. Adverse cardiac effects (arrhythmias) can result from hyperkalemia, which is a markedly elevated serum level of potassium. Common drugs that can substantially impair potassium excretion are angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARB), and potassium-sparing diuretics. Medical conditions associated with impaired potassium excretion include diabetes, chronic kidney disease, end stage renal disease, severe heart failure, and adrenal insufficiency. As a group, elderly individuals are at increased risk of hyperkalemia because they often have one or more of these conditions or take one or more of the above medications.

Summary

Healthy persons who have routine access to fluids and who are not exposed to heat stress consume adequate water to meet their needs. Thus, the Committee makes no special recommendations concerning water intake. To help lower blood pressure, the Committee recommends that individuals reduce their salt intake as much as possible, aiming for less than 2,300 mg of sodium daily. The Committee recommends a concurrent increase in potassium intake to 4,700 mg daily. In addition to helping lower blood pressure and blunting the effects of salt on blood pressure, this amount of potassium intake may reduce the risk of developing kidney stones and possibly reduce bone loss. Blacks are especially likely to benefit from reductions in sodium intake and increases in potassium intake.

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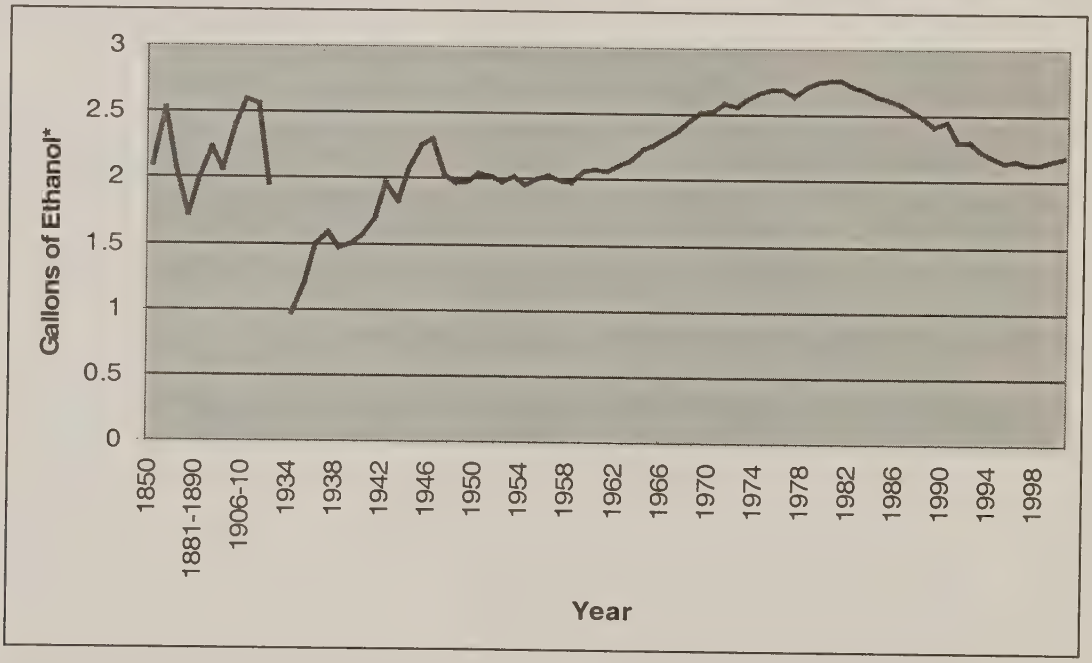
Section 8: Ethanol

Introduction

The hazards of heavy ethanol (alcohol) intake have been known for centuries. Heavy drinking increases the risk of liver cirrhosis, hypertension, cancers of the upper gastrointestinal tract, injury, and violence (USDA, HHS, 2000). A recent analysis found that alcohol use is the third leading actual cause of mortality in the United States, after tobacco use and poor diet and/or inactivity (Mokdad et al., 2004). The health consequences of consuming lesser amounts of alcohol are less often a focus of research or government recommendations.

In 1999–2001, 6 of 10 U.S. adults were current drinkers, 95 percent consuming light-to-moderate amounts (i.e., less than 7 drinks per week for women and less than 14 drinks per week for men) (Schoenborn et al., 2004) and 5 percent consuming more. Approximately 35 percent of adult Americans do not drink alcohol, with one in four being a lifelong abstainer (NIAAA, 1997). From a historical perspective, multiple sources suggest that fewer Americans consume alcohol today as compared to 50 to 100 years ago. (See Figure D8-1.)

Figure D8-1. Historical Perspective of Per Capita Ethanol Consumption in the United States



*Gallons of ethanol are based on population age 15 years and older prior to 1970 and on population age 14 years and older thereafter.

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The *2000 Dietary Guidelines for Americans* defined moderate alcohol consumption as the consumption of up to one drink per day for women and up to two drinks per day for men (USDA, HHS, 2000). One drink is defined as 12 oz. of regular beer, 5 oz. of wine (12 percent alcohol), or 1.5 oz. of 80-proof distilled spirits. The Committee largely agreed with these earlier *Guidelines*. This section examines a few specific questions to potentially modify the earlier work. The focus remains the health consequences of consuming moderate amounts of alcohol.

Overview of Questions Addressed

This section addresses two major questions related to ethanol and health:

1. Among persons who consume four or fewer alcoholic beverages per day (with a subsearch for persons age 65 and older), what is the dose-response relationship between alcohol intake and (1) total mortality and (2) several major causes of death (i.e., cardiovascular disease, cancer, and trauma)?
2. Using recent national data, what is the relationship between consuming four or fewer alcoholic beverages daily and (1) macronutrient profiles, (2) micronutrient profiles, and (3) overall diet quality?

The search strategies used to find the scientific evidence related to these broad questions appears in Part C, Methodology. Tables summarizing the findings from the searches appears in Appendix G-3.

Question 1: Among Persons Who Consume Four or Fewer Alcoholic Beverages Per Day, What Is the Dose Response Relationship Between Alcohol Intake and Health?

Conclusions

1. In middle-aged and older adults, a daily intake of one to two alcoholic beverages is associated with the lowest all-cause mortality.
2. Compared with nondrinkers, adults who consume one to two alcoholic beverages per day appear to have lower risk of coronary heart disease (CHD).
3. Compared with nondrinkers, women who consume one alcoholic beverage per day appear to have a slightly higher risk of breast cancer.
4. Relationships of alcohol consumption with major causes of death do not differ for middle-aged and elderly Americans. Among younger people, however, alcohol consumption appears to provide little, if any, health benefit; alcohol use among young adults is associated with a higher risk of traumatic injury and death.

Rationale

These conclusions are supported by the *State of the Science Report on the Effects of Moderate Drinking* (NIAAA, 2003), an extensive review of the literature conducted by scientific staff of the National Institute on Alcohol Abuse and Alcoholism (NIAAA) and reviewed by 14 outside experts. In addition to recognizing the apparent mortality benefit of moderate alcohol consumption among middle-aged and older adults, the report concludes, "Except for those individuals at particular risk…, consumption of [up to] 2 drinks a day for men and 1 for women is unlikely to increase health risks" (NIAAA, 2003, p. 30). Individuals at particular risk include persons who cannot restrict their drinking to moderate levels, children and adolescents, persons taking prescription or over-the-counter medications that can interact with alcohol, and individuals with special medical conditions (e.g., liver disease).

Conclusion #1 was further substantiated by 17 papers from the Committee systematic review of the scientific evidence examining the relationship between moderate alcohol consumption and mortality for those age 65 and older (see Table D8-1). These findings are primarily from prospective cohort studies, and they are largely consistent with findings from studies of adults under age 65. Moreover, the Committee found no evidence that moderate alcohol consumption adversely affects cognitive functioning as one ages.

More specific evidence on the relation of alcohol intake to health concerns is summarized in the discussion below.

Total Mortality

Studies conducted around the world consistently show that alcohol has a favorable association with total mortality among middle-aged and older adults. A meta-analysis on all-cause mortality using approximately 50 studies demonstrated an inverse association between moderate drinking and total mortality under all scenarios (Gmel et al., 2003). On average, the relative risk of all-cause mortality associated with moderate drinking was approximately 0.80. The J-shaped curve, with the lowest mortality risk occurring at the level of one to two drinks per day, is likely due to the protective effects of moderate alcohol consumption on CHD

Table D8-1. The relationship between moderate alcohol consumption and mortality (Age 65+)
Inclusion criteria: prospective, case-control, cross-sectional studies; human subjects; publication dates 1997 and after

Citation	Design	Population	Exposure	Outcome	Duration	Results	Statistics	Comments
Camargo et al., 1997	Prospective cohort	22,071 men in *Physicians' Health Study*, aged 40-84 years with no history of MI, stroke, transient ischemic attack, or cancer	<1 drink/wk; 1 drink/wk; 2–4 drinks/wk; 5–6 drinks/wk; 7–13 drinks/wk; ≥ 14 drinks/wk	all-cause mortality	10.7 years	Multivariate RR (age >52 y) <1 drink/wk 1.00; 1 drink/wk 0.81(0.63–1.03); 2–4 drinks/wk 0.71 (0.57–0.89); 5–6 drinks/wk 0.88 (0.69–1.12); 7–13 drinks/wk 1.02 (0.86–1.22); ≥14 drinks/wk 1.63 (1.23–2.14)	95 percent confidence interval; P-value for association - linear p=0.04; non-linear p<0.001	RR of cause-specific mortality also provided. Cohort had exceptionally low mortality rate, only 34 percent of that expected in a general population of white men with same age distribution during a similar period.
Chyou et al., 1997	Prospective cohort	8,006 Japanese-American men living in Hawaii, between 45–68 years at initial examination in 1965–1968	occasionally; lightly; moderately; heavily	overall mortality	22 years	J-shaped pattern in risk for intake of alcohol; synergistic interaction between BMI and alcohol—Men with intermediate BMI (21.21–26.30 kg/m2) and drank occasionally to lightly (0.01–24.99 oz/mo) RR 1.00 (reference group); Men with lowest BMI (<21.21 kg/m^2) and drank moderately to heavily (≥ 25 oz/mo) RR 1.63 (1.33–1.99)	Synergistic interaction between BMI and alcohol, p=0.0017; RR -95 percent confidence interval	Increase in risk due to the interactive effect of low BMI and high alcohol intake was stronger (and statistically significant) than when each of these risk factors was considered separately

Table D8-1 (cont.). The relationship between moderate alcohol consumption and mortality (Age 65+)
Inclusion criteria: prospective, case-control, cross-sectional studies; human subjects; publication dates 1997 and after

Citation	Design	Population	Exposure	Outcome	Duration	Results	Statistics	Comments
Dawson, 2001	Prospective cohort	42,910 adults 18 years and older; data from 1988 *National Health Interview Study* linked with the National Death Index for 1988 through 1985	abstainers; infrequent drinkers; light; moderate	mortality	7.5 year follow-up	Relative to lifetime abstainers and infrequent drinkers, the risk of death from external causes increased directly with volume of intake. No evidence for reduced risk of death among light or moderate drinkers.		
Dawson, 2000		37,682 U.S. adults age 25 years and older; data from 1988 *National Health Interview Study* linked with the National Death Index for 1988 through 1985	lifetime abstainers; past-year abstainers; light; moderate; heavy; very heavy	all-cause mortality		OR past-year abstainers 1.00; light 0.76 (0.68–0.84); moderate 0.84 (0.74–0.96); very heavy 1.17 (0.93–1.47)	95 percent confidence interval	When lifetime abstainers used as reference, the protective effect of moderate drinking fell short of significance. When dependence was considered, light and moderate drinkers without dependence had a reduced mortality risk regardless of reference group.
Farchi et al., 2000	Prospective cohort	1536 males aged 45–65 in 1965 in Northern and Central Italy	<12 g/d; 13–48 g/d; 49–84 g/d; 85–120 g/d; over 120 g/d	age-adjusted life expectancy; total mortality	30 years	Age-adjusted life expectancy (years+/-SE) <12 g/d–19.6+/-0.9; 13–48 g/d–20.9+/-0.5; 49–84 g/d–21.6+/-0.4; 85–120 g/d–19.4+/-0.6; over 120 g/d–20.6+/-0.2	Years+/-SE	Taking smoking habit into account, longest survival was observed in non-smokers drinking 4–7 drinks daily. Stratifying for physical activity, the longest survival was in men engaged in heavy physical activity at work drinking 1–4 drinks per day.

Table D8-1 (cont.). The relationship between moderate alcohol consumption and mortality (Age 65+)
Inclusion criteria: prospective, case-control, cross-sectional studies; human subjects; publication dates 1997 and after

Citation	Design	Population	Exposure	Outcome	Duration	Results	Statistics	Comments
Gaziano et al., 2000	Prospective cohort	89,299 U.S. men from the *Physicians' Health Study* who were age 40–84 years in 1982 and free of known MI, stroke, cancer or liver disease	rarely/never drinkers; 1 drink/wk; 2–4 drinks/ wk; 5–6 drinks/wk; 1 drink/d; ≥2 drinks/d	total mortality	5.5 years of follow-up	RR of total mortality rarely/never drinkers 1.00; 1 drink/wk 0.74; 2–4 drinks/ wk 0.77; 5–6 drinks/wk 0.78; 1 drink/d 0.82; > or = 2 drinks/d 0.95	Total mortality significant at 95 percent CI, except >or= 2 per day (0.79-1.14)	CVD mortality L-shaped with apparent risk reductions even at highest category of > or = 2 drinks per day; no clear harm or benefit for total or common site-specific cancers
Hoffmeister et al., 1999	Prospective cohort	15,400 representative sample of German population and 2,370 regional sample of the Berlin-Spandau, age 25–69 years	0 g/d; 1–20 g/d; 21–40 g/d; 41–80 g/d; >80 g/d	all-cause mortality	7 years for Berlin-Spandau population	All-cause mortality hazard ratio (HR) for men - 0 g/day 1.00; 1–20 g/d 0.51 (0.29–0.90); 21–40 g/d 0.90 (0.51–1.56); 41–80 g/d 0.93 (0.49–1.76); >80 g/d 0.44 (0.10–1.86); All-cause mortality hazard ratio (HR) for women - 0 g/day 1.00; 1–20 g/d 0.83 (0.47–1.47); 21–40 g/d 1.29 (0.61–2.72); 41–80 g/d 0.81 (0.25–2.65); >80 g/d 4.20 (1.23–4.30)	95 percent confidence interval	65 percent of men and 85 percent of women were light or moderate drinkers.
Jackson et al., 2003	Prospective cohort	112,528 U.S. men from the *Physicians' Health Study*, 1320 of whom reported a baseline history of stroke	rarely or never drink; very light (<1 drink/d); light (1–6 drinks/wk); moderate (≥ 1 drink/d)	total mortality	4.5 years	RR rarely or never drink 1.00; <1 drink/d 0.88 (0.60–1.28); 1–6 drinks/wk 0.64 (0.48–0.85); ≥ 1 drink/d 0.71(0.54–0.94)	95 percent confidence interval; *p*=0.03 for trend	RR for cardiovascular mortality - very light 0.89 (0.58-1.36); light 0.56 (0.40-0.79); moderate 0.64 (0.46–0.99); *p*=-0.008 for trend

Table D8-1 (cont.). The relationship between moderate alcohol consumption and mortality (Age 65+)
Inclusion criteria: prospective, case-control, cross-sectional studies; human subjects; publication dates 1997 and after

Citation	Design	Population	Exposure	Outcome	Duration	Results	Statistics	Comments
Keil et al., 1997	Prospective cohort	1,071 and 1,013 women, age 45–65 years, from the Ausburg region of Germany	nondrinkers; drinkers (further divided by grams of alcohol/d)	total mortality	8 years	Hazard rate ratio nondrinkers 1.00; drinkers 0.59 (0.36–0.97); For different alcohol groups - 20–39.9 g/d 0.46 (0.20–0.80); ≥ 80 g/day 1.04 (0.54–2.00)	95 percent confidence interval	Total mortality HRR showed U-shaped curve.
Maskarinec et al., 1998	Prospective cohort	40,000 persons with Caucasian, Chinese, Filipino, Japanese, and native Hawaiian ethnicity	None, low alcohol intake (1–7 drinks/wk); higher levels of intake (>7 drinks/wk)	all-cause mortality	20 years	Men and women with low alcohol intake (1–7 drinks/wk) had 20 percent reduction in total mortality.		At higher levels of intake, women and Asian men experienced no mortality benefit.
Mukamal et al., 2001	Prospective cohort	1,913 adults hospitalized with AMI between 1989 and 1994 in 45 U.S. community and tertiary care hospitals	none; less than 7 drinks/wk; 7 or more drinks/wk; (1 drink = 15 g alcohol)	all-cause mortality	3.8 years	Hazard ratio (full model) abstainers 1.00; <7 drinks 0.79 (0.60–1.03); ≥ 7 drinks 0.68 (0.45–1.05)	95 percent confidence interval, p=0.01 for trend	
Muntwyler et al., 1998	Prospective cohort	5,358 men from *Physicians' Health Study* who reported a history of MI and provided information on alcohol intake	rarely/never drinkers; 1–4 drinks/ month; 2–6 drinks/wk; 1 drink/d; ≥2 drinks/ d	total mortality	5 years	Multivariate RR-age 65–84y rarely/never drinkers 1.00; 1–4 drinks/mo 0.84 (0.65–1.07); 2–6 drinks/wk 0.70 (0.54–0.91); 1 drink/day 0.81 (0.64–1.02); > 2 drinks/d 0.89 (0.55–1.47)	95 percent confidence interval	Total mortality and alcohol association did not differ significantly by age classification (40-64 y vs. 65–84 y)

Table D8-1 (cont.). The relationship between moderate alcohol consumption and mortality (Age 65+)
Inclusion criteria: prospective, case-control, cross-sectional studies; human subjects; publication dates 1997 and after

Citation	Design	Population	Exposure	Outcome	Duration	Results	Statistics	Comments
San Jose et al., 1999	Prospective cohort	18,973 residents in Eindhoven, Netherlands	abstainers; light (1–14 units/wk); moderate (15–28 units/wk); excessive (> or =29 units/wk)	mortality		light or moderate drinkers had lower mortality than either abstainers or heavier drinkers		
Simons et al., 2000	Prospective cohort	1,235 men and 1,570 women age 60 years and over living in Dubbo, New South Wales, first examined in 1988-89	zero consumption; 1–7 drinks/week; 8–14 drinks/wk; 15–28 drinks/wk, >28 drinks/wk (1 drink = 10 g alcohol)	mortality	116 months	Hazard ratio: Men (60–74 y.o.) - no consumption 1.00; 1–7 drinks/wk 0.68 (.49–.94); 8–14 drinks/wk 0.58 (.39–.85); 15–28 drinks/wk 0.62 (.40–.95) >28 drinks/wk 0.56 (.33–.96); Women (60+ y.o.) – no consumption 1.00; 1–7 drinks/wk 0.78 (.61–.99); 8–14 drinks/wk 0.66 (.45–.97); 15–28 drinks/wk 0.67 (.29–1.55)	95 percent confidence interval	Any intake of alcohol was associated with reduced mortality in men up to 75 years and in women over 64 years. After almost 10 years follow-up, men taking any alcohol lived on average 7.6 years longer and women on average 2.7 months longer, than non-drinkers. Study also provides HR for pattern of alcohol intake.
Theobald et al., 2000	Prospective cohort	1,828 individuals age 18-65 years	lifelong abstainers; ex-drinkers; <50 g/wk; <140 g/wk	total mortality	22 years	RR compared with intake of wine less than once a week or not at all – Intake of wine once a week or more 0.58 (0.40–0.84); RR compared to lifelong abstainers and <50 g - ex-drinkers 2.64 (1.56–4.49)	95 percent confidence interval	

Table D8-1 (cont.). The relationship between moderate alcohol consumption and mortality (Age 65+)
Inclusion criteria: prospective, case-control, cross-sectional studies; human subjects; publication dates 1997 and after

Citation	Design	Population	Exposure	Outcome	Duration	Results	Statistics	Comments
Thun et al., 1997	Prospective cohort	490,000 people (251,420 women and 238,206 men) age 30–104 in 1982 that were part of the *Cancer Prevention Study* II	nondrinkers; less than daily (but at least 3/wk); remaining reported in units per day (i.e. 1/day, 2/day, etc); (1 drink = 12 g alcohol)	all-cause mortality	9 years	RR for 60-79 y.o. with low cardiovascular risk - nondrinkers 1.00; less than daily 0.8 (0.8–0.9); 1 drink/d 0.8 (0.8–0.9); 2 drinks/d 0.8 (0.8–0.9), 3 drinks/d 0.9 (0.9–1.0); ≥ 4 drinks/d 1.0 (0.9–1.1); RR for 60–79 y.o. with high cardiovascular risk - nondrinkers 1.00; less than daily 0.8 (0.8–0.9); 1 drink/d 0.8 (0.8–0.8); 2 drinks/d 0.8 (0.8–0.8), 3 drinks/d 0.8 (0.7–0.9); > 4 drinks/d 0.8 (0.7–0.8)	95 percent confidence interval	
Woo et al., 2002	Prospective cohort	2,032 Chinese subjects aged 70 years and older (mean age 80 years)	abstinence; occasional (less than once to up to twice per week); regular (three of more times weekly)	mortality	3 years	OR abstinence 1.00; occasional 0.625 (0.41,0.95); regular 0.684 (0.44,1.07)	95 percent confidence interval - However not statistically significant after adjusting for age and baseline self-perceived health	

(Marmot, 2001; Mukamal, 2003) and ischemic stroke (Reynolds et al., 2003), the first and third leading causes of death in the United States, respectively.

The Committee found weak evidence that purported changes in body composition with age support lowering the drinking limit for older men to one drink per day (NIAAA, 2003). A discussion with experts at NIAAA indicated that body composition of the elderly may be less relevant now because, as Americans are aging better, many are losing less lean body mass. In addition, elderly drinkers' level of impairment at any given blood alcohol concentration does not differ from that of younger drinkers (NIAAA, 2003).

Coronary Heart Disease

An inverse association between light-to-moderate alcohol consumption and CHD morbidity and mortality has been demonstrated in a variety of populations and is independent of many other cardiac risk factors, including age, sex, race/ethnic group, smoking habits, and body mass index (Corrao et al., 2004, 2000; Marmot, 2001; Mukamal and Rimm, 2001). On average, the relative risk of CHD associated with moderate drinking is between 0.50 and 0.80. The largest potential benefits are found among women age 55 and older, men age 45 and older, and those at risk for heart disease. At younger ages, potential reductions in CHD are probably offset by increases in traumatic death (e.g., Andreasson et al., 1988).

The totality of the evidence does not support beverage-specific effects of certain types of alcohol. While laboratory findings have suggested that red wine might have additional health-promoting compounds, this finding is not consistently translated into the epidemiologic data. For example, Keil and colleagues (1997) present evidence of lower total mortality and CHD rates among moderate drinkers in a beer-drinking population; other population studies have found the largest reductions among those consuming largely distilled spirits (Rimm et al., 1996).

These conclusions were reached and supported by evidence in the NIAAA's *State of the Science Report* (NIAAA, 2003) and by many other recent studies. Although the CHD risk reduction probably is causal (Rimm et al., 1999), several other factors can reduce the risk of CHD (and other chronic diseases) independent of alcohol consumption, including a healthy diet, physical activity, avoidance of smoking, and maintenance of a healthy weight.

Cancer

Although immoderate alcohol intake has been linked to various types of cancer (Corrao et al., 2004), moderate intake (i.e., up to one drink per day for women, up to two drinks per day for men) is not associated with most major cancers (NIAAA, 2003).

Breast cancer is a likely exception. Compared with nondrinkers, women who consume 1 drink per day appear to have an approximately 10 percent increase in the risk of breast cancer (NIAAA, 2003). Several meta-analyses suggest a linear dose-response relationship between the amount of alcohol intake and breast cancer risk (e.g., Smith-Warner et al., 1998). However, at the lower levels of intake (e.g., 2 drinks per week), the increase is sufficiently small that it is difficult to ascribe the finding to an effect of alcohol per se. The alcohol–breast cancer association may be of particular significance to women with a family history of breast cancer and those on hormone replacement therapy. Epidemiologic evidence indicates that the relative effect of moderate alcohol consumption on breast cancer risk may be small at the individual level but substantial at the population level.

Question 2: What Is the Relationship Between Consuming Four or Fewer Alcoholic Beverages Daily and Macronutrient Profiles, Micronutrient Profiles, and Overall Diet Quality?

Conclusion

A daily intake of one to two alcoholic beverages is not associated with inadequate intake of macronutrients or micronutrients, or with overall dietary quality.

Rationale

Ten papers from the Committee's systematic review of the scientific evidence provided data useful to the conclusion that the consumption of one to two alcoholic beverages per day is not associated with macronutrient or micronutrient deficiencies:

- Seven cross-sectional studies (Barefoot et al., 2002; D'Avanzo et al., 1997; de Castro and Orozco, 1990; Jacques et al., 1989; Rosell et al., 2003; Schroder et al., 2002; Tremblay et al., 1995)
- Three clinical trials (Foltin et al., 1993; Orozco and de Castro, 1991; Tremblay et al., 1995)

At the Committee's request, U.S. Department of Agriculture's Center for Nutrition Policy and Promotion used a modeling process described in Appendix G-2 to examine the relationship of moderate alcohol consumption with nutrient intakes and diet quality of participants in the *National Health and Nutrition Examination Survey* (NHANES) 1999–2000. The analysis demonstrated that

- Energy and nutrient intakes generally increased with increasing amounts of alcohol
- Among women, the Healthy Eating Index increased with increasing amounts of alcohol
- Among men, the highest Healthy Eating Index was found among men who consumed an average of two drinks per day

Nonetheless, alcoholic beverages supply calories but few nutrients. The energy contribution from alcoholic beverages varies widely. Specifically, some alcoholic beverages, such as dessert wines and mixed drinks, provide almost three times as many calories as do the standard drink portions: 12 oz. of beer, 5 oz. of wine, or 1.5 oz. of distilled spirit (see Part E, Table E-3, for a list of selected alcoholic beverages and their calorie content).

For those who choose to drink an alcoholic beverage, it is advisable to consume it with meals to slow alcohol absorption. Data suggest that the presence of food in the stomach can slow the absorption of alcohol (Jones et al., 1997) and thereby mitigate the associated rise in blood alcohol concentration.

Supplementary Information

Adverse Effects of Moderate Alcohol Consumption

The Committee also reviewed evidence regarding adverse effects of moderate alcohol consumption (NIAAA, 2003).

- **Trauma—** According to the NIAAA report (2003), studies on relationships of alcohol with injuries from falls and with violence and/or abuse frequently do not distinguish between moderate and excessive drinking. Studies of acute effects of alcohol show that even moderate-dose consumption compromises brain performance in terms of error detection, processing speed, and response time. Low levels of drinking and blood alcohol content below 0.08 percent increase the risk of driving-related accidents. Thus, there are compelling temporary reasons not to drink alcohol, such as when planning to drive, operate machinery, or take part in activities that require attention, skill, or coordination.
- **Hepatic effects—** Alcohol abuse is the leading cause of liver-related mortality in the United States, accounting for at least 40 percent, and perhaps as many as 90 percent, of cirrhosis deaths (CDC, 1993; Vong and Bell, 2004). Lower levels of alcohol intake can result in liver function abnormalities short of cirrhosis. For example, moderate alcohol consumption may potentiate the carcinogenic potency of other hepatotoxins (NIAAA, 2003).
- **Young age—** Children or adolescents should not consume alcohol. Alcohol consumption increases the risk of traumatic injury, which is the number one cause of death in this age group. Animal data on alcohol-related structural changes in the brain, while less compelling, illustrate why drinking is inappropriate for adolescents (Land and Spear, 2004; Markwiese et al., 1998). "Designer drinks" (i.e., newer alcohol products that tend to target young adults) are of recent concern because of their possible effect on underage drinking.
- **Pregnancy (including the first few months of pregnancy—often before the pregnancy is recognized)—** Moderate drinking during pregnancy may have behavioral or neurocognitive consequences in the offspring. Heavy drinking during pregnancy can produce a range of behavioral and psychosocial problems, malformations, and mental retardation in the offspring (NIAAA, 2003).
- **Breastfeeding—** The level of alcohol in breast milk mirrors the mother's blood alcohol content. Low or moderate alcohol consumption does not enhance lactational performance and actually may decrease infant milk consumption. Recent data indicate that alcohol consumption while breastfeeding has adverse effects on the infant's feeding and behavior (NIAAA, 2003).
- **Other conditions—** The NIAAA review also provides documentation that alcohol consumption should be avoided by individuals who cannot restrict their drinking to moderate levels, individuals taking medications that can interact with alcohol, and persons with specific medical conditions, such as liver disease (NIAAA, 2003).

Reasons Not To Drink Alcoholic Beverages

Abstention is an important option; approximately one in three American adults does not drink alcohol. Moreover, studies suggest adverse effects at even

moderate alcohol consumption levels in specific individuals and situations, as described above. People who should not drink:

- Individuals who cannot restrict their drinking to moderate levels
- Children and adolescents
- Individuals taking prescription or over-the-counter medications that can interact with alcohol
- Individuals with specific medical conditions (e.g., liver disease)

Situations where alcohol should be avoided:

- Women who may become pregnant or who are pregnant
- Women who are breastfeeding
- Individuals who plan to drive, operate machinery, or take part in other activities that require attention, skill, or coordination

Unresolved Issue

What Is the Relationship Between Consuming Four or Fewer Alcoholic Beverages Daily and Obesity?

Available data on the relationship between alcohol consumption and weight gain/obesity are sparse and inconclusive. There are contradictory findings at the higher end of the spectrum (i.e., 3 to 4 drinks per day) that may relate to fundamental limitations of the cross-sectional study design. At moderate drinking levels (i.e., up to one drink per day for women, up to two drinks per day for men), there is no apparent association between alcohol intake and obesity.

Ten observational papers from our systematic review of the scientific evidence provided data useful to this conclusion.

- Cross-sectional (Barefoot et al., 2002; Dorn et al., 2003; Gavaler and Rosenblum, 2003; Lahti-Koski et al., 2002; Rosell et al., 2003; Sherwood et al., 2000)
- Case control (Andersson and Rossner, 1996)
- Prospective cohort (Hoffmeister et al., 1999; Sherwood et al., 2000; Vahtera et al., 2002; Wannamethee and Shaper, 2003)

In summary, although prospective data are limited, there is no apparent association between consuming one or two alcoholic beverages daily and obesity.

Summary

A daily intake of one to two alcoholic beverages is associated with the lowest all-cause mortality and a low risk of CHD among middle-aged and older adults. Among younger people, however, alcohol consumption appears to provide little, if any, health benefit; alcohol use among young adults is associated with a higher risk of traumatic injury and death. Thus, the Committee recommends that if alcohol is consumed, it should be consumed in moderation, and only by adults. Moderation is defined as the consumption of up to 1 drink per day for women and up to 2 drinks per day for men; and 1 drink is defined as 12 oz. of regular beer, 5 oz. of wine (12 percent alcohol), or 1.5 oz. of 80-proof distilled spirits. A number of situations and conditions call for the complete avoidance of alcoholic beverages.

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Section 9: Food Safety

This section addresses two major questions related to food safety, which led to two conclusive statements:

1. What behaviors are most likely to prevent food safety problems? Or, in terms of how food is handled, what behavior(s) are most likely to cause food safety problems (foodborne illness)?

   Subsumed under this question were more specific questions, such as "What data are there regarding the effectiveness of bacterial cleansers in preventing foodborne illness?" and "What are the data regarding cleaning fruits and vegetables to reduce the risk of foodborne illness?"

   The general search strategy used to find the scientific evidence related to this broad question appears in Part C, "Methodology."(See the summary table in Appendix G-3 for a table summarizing the findings from a search on hand washing.)

   As a part of its search, the Dietary Guidelines Advisory Committee (the Committee) also collected data related to an educational tool for conveying messages to consumers about safe food handling and preparation. In particular, the Committee obtained information on a national public education campaign called FightBAC!® and addressed the following question:

2. What topics, if any, need attention even though they are not an integral part of the FightBAC! campaign? (FightBAC! is a national public education campaign to promote food safety to consumers and educate them on how to handle and prepare food safely. In this campaign, pathogens are represented by a cartoon-like bacteria character named "BAC.")

Scope of the Problem

Foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year (Mead et al., 1999). Known pathogens account for an estimated 14 million illnesses, 60,000 hospitalizations, and 1,800 deaths. Three pathogens—*Salmonella, Listeria, and Toxoplasma*—are responsible for more than 75 percent of these deaths. Unknown agents account for the remaining 62 million illnesses, 265,000 hospitalizations, and 3,200 deaths. The actual percentage of outbreaks of foodborne illness is likely to be much larger than described above because small outbreaks that occur in homes often are unreported or not investigated (Tauxe, 1991).

Although most foodborne infections cause mild illness, severe infections and serious complications—including death—do occur. As described by the FoodNet Working Group (Angulo et al., 1998), the public health challenges of foodborne diseases are changing rapidly as a result of newly identified pathogens and vehicles of transmission, changes in food production, and an apparent decline in food safety awareness. Americans are exposed to foodborne pathogens from distant parts of the United States and the world. Increased demand for ready-to-eat and minimally processed foods and increased consumption of food in eating establishments outside of the home also have contributed to new exposures to foodborne disease. For example, foodborne disease outbreaks of *Salmonella and Escherichia coli O157:H7* infections have been associated with an increasingly wide variety of foods, including some previously thought to be safe, such as alfalfa sprouts and unpasteurized fruit juice.

Question 1: What Behaviors Are Most Likely to Prevent Food Safety Problems?

Conclusion

The behaviors in the home that are most likely to prevent a problem with foodborne illnesses are:

- Cleaning hands, contact surfaces, and fruits and vegetables (but not meat and poultry, which should not be washed)
- Separating raw, cooked, and ready-to-eat foods while shopping, preparing, or storing
- Cooking foods to a safe temperature
- Chilling (refrigerate) perishable foods promptly

Rationale

The Four Basic "FightBAC!" Educational Messages

The four main messages of the food safety guidelines emphasize proper food-handling behaviors (clean, separate, cook, chill) and coincide with the FightBAC! campaign of The Partnership for Food Safety Education, created in 1997 by the U.S. Departments of Agriculture, Education, and Health and Human Services, and 10 food industry organizations (*www.fightbac.org*). The FightBAC! messages were developed from a consensus of food safety experts and have been tested for consumer comprehension. Large improvements in consumer food safety practices have been seen since the campaign has been in effect, and a recent survey found that these gains have been maintained or improved for all four food-handling practices (FDA, 2002). A survey of 500 Latino consumers (Dharod et al., 2004) showed that the influence of the FightBAC! campaign is likely to improve food safety awareness and bring about changes in food safety knowledge and attitudes.

Affirmation of the usefulness of the FightBAC! messages was demonstrated by Bryan (1988) who surveyed all the pertinent literature of the time on factors that contribute to outbreaks of foodborne disease. His sources included food surveillance data on foodborne illness submitted to the Centers for Disease Control and Prevention (CDC), surveillance data from health agencies, investigations made by CDC personnel, and articles published in public health, medical, or food science journals. He ranked the order of practices likely to contribute to foodborne illness as follows:

- Improper cooling
- Colonized person handling food (improper hand washing)
- Inadequate cooking
- Failing to avoid cross-contamination

In a viewpoint paper based on data from CDC, Medeiros et al. (2001a) developed food safety consumer education messages as follows:

- Primary messages
  - — Hand washing
  - — Adequate cooking
  - — Avoiding cross-contamination
- Secondary messages
  - — Keeping food safe to eat
  - — Avoiding food from unsafe sources

Using a four-round Delphi technique, Hillers et al. (2003) identified and ranked food-handling and consumption behaviors associated with 13 major foodborne pathogens. They surveyed 40 nationally ranked experts: 11 in food microbiology, 9 in epidemiology, 10 in food safety education, and 10 in food safety policy. Hiller and colleagues concluded that the acts of primary importance in the prevention of foodborne illness were

- Using a thermometer to cook foods adequately
- Hand washing
- Avoiding cross-contamination
- Avoiding certain foods likely to be contaminated

The identification and ranking of the causes of food safety problems and corrective measures above is limited by shortcomings in the source data that result from incomplete and inadequate reporting of outbreaks and incomplete write-up or abstracting of contributing factors. Moreover, in the Hillers et al. (2003) study, some bias could have resulted from the use of expert opinions, processing of the opinions by a research team, and a requirement that respondents respond in fixed ways. Nonetheless, these findings are based on input from geographically dispersed experts and could lead to a clearer understanding of key concepts needed to educate consumers for safer food handling and reducing risks of foodborne illness.

Further affirmation of the FightBAC! messages was presented by Sulka et al. (2003). Contributing factors for *E. coli 0157:H7* and *Salmonella enteritidis* outbreaks are listed as inadequate/improper cooking, contamination, preharvest contamination, ill food handler, and improper storage or holding of food. The Committee found evidence to support additional food safety guidance, as summarized below.

The "Clean" Message

Hand Washing—The Committee identified five useful papers that addressed hand washing. The strongest paper was the double-blind, placebo-controlled study by White et al. (2001) that included structured hand hygiene education. The study assessed whether an alcohol-free hand sanitizer containing the surfactants allantoin and benzalkonium chloride could reduce

illness and absenteeism among elementary school children and serve as an effective alternative when regular soap-and-water hand washing was not readily available. Although the study did not compare the sanitizer to soap and water, the importance of hand washing was evident from the results: after 5 weeks, students using the active product were 35 percent less likely to have been absent because of illness when compared with the placebo group. Although the study lacked a cross-over confirmation and lost a large portion (55 percent) of the original study participants because of a lack of compliance in many of the study classrooms, it demonstrated that there are simple ways to overcome obstacles of adequate hand washing, including education. The results demonstrate that there is opportunity for proper hand washing at the school level and, consequently, for improving attendance and promoting the health of students.

Charbanneau and colleagues (2000) provided direct data demonstrating the value of washing hands with a mild soap. They found that 20-second soap-and-water hand washing was more effective than using hand sanitizers containing 70 percent ethanol in eliminating viable bacteria from meat-soiled hands. The Food and Drug Administration (FDA) and the CDC (2004) recommend soap and water cleansing for food handling, noting that alcohols have very poor activity against bacterial spores, protozoan oocyts, and certain nonenveloped viruses.

Further evidence supporting soap-and-water hand washing is provided by a study conducted by Master et al. (1997). When compared with usual hand washing practices, washing the hands a minimum of four scheduled times a day, in addition to usual hand washing, produced a statistically significant ($p = 0.0024$) decrease in the number of absences due to gastrointestinal illness (18.5 days of absence in the hand washing group versus 49 days of absences in the control group). Reported overall illness-related absence was lower but not significantly different. The major limitations of the study include the use of a single institution, the use of a discrete population without socioeconomically diverse backgrounds and lack of double-blindedness.

A study in an adult day care center (Falsey et al., 1999) and another of telephone interviewees (Mead et al., 1997) provide indirect evidence supporting the value of hand washing in the prevention of infections. Although these two studies have some limitations, the authors provide a sound basis for their estimates that thorough hand washing reduces infections by about one-half and one-third, respectively.

These five studies support the inclusion of the detailed hand washing protocol developed by the CDC (*www.cdc.gov/ncidod/op/hand washing.htm*) in food safety guidance. In addition, to reduce the risk of cross-contamination, add to the protocol guidance regarding drying hands using a clean disposable or cloth towel.

Box 1. Food Safety

Hand Washing Protocol

- First, wet your hands and apply liquid or clean bar soap. Place the bar of soap on a rack to drain.
- Next, rub your hands vigorously together and scrub all surfaces.
- Continue for 10 to 15 seconds or about the length of a little tune. It is the soap combined with the scrubbing action that helps dislodge and remove germs.
- Rinse hands well, and dry them using a clean disposable or cloth towel.

(Adapted from Centers for Disease Control and Prevention, "An ounce of prevention: keeps the germs away.")

Washing Fresh Fruits and Vegetables—Through a systematic search of the literature, the Committee identified 10 relevant articles on washing fruits and vegetables, and experts directed them to additional useful scientific literature. (See Summary Table in Appendix G-3.) Recent outbreaks of foodborne illness associated with eating fresh produce have heightened concerns that these foods may be an increasing source of illness (Tauxe et al., 1997). Studies have shown that bacteria can survive and/or grow on fresh produce and that fresh produce supports the growth of pathogens such as *E coli 0157:H7, Salmonella Montevideo, and Shilgella flexneri* (Li-Cohen and Bruhn, 2002; Li-Cohen et al., 2002). Moreover, some consumers practice unsafe handling of fresh produce (Li-Cohen and Bruhn, 2002).

Consumer surveys demonstrate a growing public concern about food safety and the need for an explanation behind food safety guidance (Li-Cohen et al., 2002). Therefore, consumers should be given clear directions on how to remove pathogens from raw fruits and vegetables. Although washing is only partially effective at removing pathogens from fresh produce,

washing is the only method that consumers have to reduce pathogen load on fresh produce (Medeiros et al., 2001a). Food safety information should be simple to read and easy to follow, such as that developed by Li-Cohen et al. (2002). Consumers may be unwilling to adopt safe practices if instructions are too time-consuming or are viewed as costly or inappropriate (Li-Cohen et al., 2002).

Box 2. Food Safety

Protocol for Washing Fresh Fruits and Vegetables

1. Remove and discard the outer leaves from vegetables, such as lettuce and cabbage, before washing.
2. Wash fruits and vegetables (including organically grown, farmer's market, and homegrown produce) just before cooking or eating.
3. Wash under running potable water.
4. When possible, scrub fruits and vegetables with a clean scrub brush or with hands.
5. Dry fruits and vegetables.

(Adapted from Li-Cohen et al., 2002)

Free moisture on produce may promote survival and growth of microbial populations in an otherwise inhospitable environment (FDA, 2001). Therefore, Step 5 above is critical if the food will not be eaten or cooked right away. In addition, consumers should read the labels of bagged produce to determine if it is ready-to-eat. Ready-to-eat, prewashed bagged produce can be used without further washing if kept refrigerated and used by the "used-by" date. If desired, prewashed, ready-to-eat produce can be washed again (FDA, 2001).

Guidance for Safely Using Bagged Produce

- Read the labels of bagged produce to determine if it is ready-to-eat.
- Ready-to-eat, prewashed, bagged produce can be used without further washing if kept refrigerated and used by the "use-by" date.
- If desired, prewashed, ready-to-eat produce can be washed again.

Use-by dates should be differentiated from purchase-by dates. Products with purchase-by dates can be used after that date; however, products with use-by dates should not be used after the use-by date.

Although some studies have shown that antibacterial agents are proven effective in reducing indigenous flora on produce such as lettuce during food service preparation (Smith et al., 2003), these solutions warrant additional testing and research in household settings.

Washing Meat and Poultry—Washing raw poultry and meat creates the danger of cross-contamination and is not necessary because bacteria on the surface of the meat will be destroyed by cooking. Washing these foods can allow bacteria that is present on the surface of the meat or poultry to spread to other ready-to-eat foods (FSIS, 1999). Washing raw meat and poultry is reported to be one of the most commonly observed food preparation practices that can lead to cross-contamination (Yankelovich Partners, 1997). Literature is not available on the effects of washing fish, but it would seem that the same risk for cross-contamination would exist.

Cleaning Refrigerators—Cleaning is closely linked with the problem of cross-contamination—the transfer of harmful bacteria to food from other foods, often through an intermediary. Refrigerator surfaces can become contaminated from contact with high-risk foods such as raw meats, poultry, fish, uncooked hotdogs, certain deli meats, or raw vegetables. If not cleaned, affected refrigerator surfaces can, in turn, serve as a vehicle for contaminating other foods.

Even at recommended refrigerator temperatures of 40°F or lower, foods such as meat, poultry, fish, and cheese made from unpasteurized milk have in common the ability to support the growth of the bacterium *Listeria monocytogenes* during extended refrigerated storage (HHS/USDA, 2003). Ingesting food contaminated with this organism can be the source of very serious foodborne illness in high-risk populations (see Table E-26). In a refrigerator that is not kept clean, for example, if the liquid from uncooked frankfurters contains *Listeria monocytogenes* and contaminates refrigerator surfaces, foods coming in contact with those surfaces may become unsafe to eat (Byers et al., 1994).

Although other pathogenic organisms grow very slowly at recommended refrigerator temperatures, cross-contamination that occurs in the refrigerator can lead to foodborne illness, especially if combined with other unsafe food practices, such as allowing the food to stand at room temperature before eating or heating the food inadequately. An emphasis on cleaning

refrigerators is consistent with the contribution that cross-contamination makes to foodborne illness, as reported by Sulka et al. (2003).

Minimizing the Refrigerator as a Source of Cross-Contamination

- The refrigerator should be cleaned regularly, including the washing of shelf surfaces and drawers.
- Liquids should not be allowed to drip or spill from higher refrigerator shelves onto lower shelves; wipe up spills immediately—clean surfaces thoroughly with hot, soapy water; then rinse.
- Liquids from foods such as frankfurters and luncheon meats should not be allowed to come in contact with other foods or surfaces after the package is opened (USDA, 2004).

The "Separate" Message

Bacterial contamination in raw meat and poultry juices, produce, perishable ready-to-eat foods, and cooked foods can be spread to other foods, utensils, and surfaces. Its relationship with the "clean" message is discussed briefly above.

The "Chill" Message

Based on discussion with food safety experts and Bryan's analysis (Bryan, 1988), the Committee recognized the value of including more than one "chill" step in the FightBAC! sequence (e.g., clean, separate, chill, cook, chill). Chilling provides substantial protection at any stage of food handling during which raw foods are not being cleaned or cooked.

The "Cook" Message

Consumers make many food-handling errors during food preparation that increase their risk of foodborne illness. Furthermore, very few consumers use a food thermometer and they frequently undercook meat and poultry (Anderson et al., 2004). The best way to tell if meat, poultry, or egg dishes are cooked to a safe temperature is to use a thermometer. The U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA) summarize the following recommendations for cooking safely:

A thermometer is used to measure the internal temperature of cooked meat and poultry and egg dishes to make sure that the meat or dish is cooked all the way through. Minimum safe internal temperatures are as follows:

- roasts and steaks—145°F
- whole poultry—180°F
- ground meat (since bacteria can spread during grinding) —160°F
- leftovers—165°F
- sauces, soups, and gravy— 160°F
- egg dishes—160°F

If using a microwave oven, care is needed to be sure that all parts of the food reach the specified temperature.

Information from the CDC links eating undercooked, pink ground beef with a higher risk of illness. If a thermometer is not available, it is advisable not to eat ground beef that is still pink inside. Cook fish until it is opaque and flakes easily with a fork.

In 1996 to 1997, FoodNet, a collaborative program among the CDC, USDA, FDA, and selected State health departments, conducted a telephone survey of 7,493 adults in 5 states (California, Connecticut, Georgia, Minnesota, and Oregon) to determine the prevalence of risk factors of foodborne illness. Results indicated that undercooked eggs (runny eggs) were the most commonly consumed high-risk food, eaten by 19 percent of the respondents in the 5 days before the interview. The researchers concluded that health education should emphasize the importance of cooking eggs well to prevent salmonellosis.

Question 2: What Topics, if Any, Need Attention Even Though They Are Not an Integral Part of the "Fightbac!" Campaign?

Conclusion

Avoiding higher risk foods is an important protective measure (e.g., deli meats and frankfurters that have not been reheated to a safe temperature may contain *Listeria*). This is especially important for high-risk groups (the very young, pregnant women, the elderly, and those who are immunocompromised).

Rationale

Potentially unsafe foods fall in three categories: those having been stored in a manner or for a period of time that would allow dangerous growth of bacteria, foods at high risk for contamination by *Listeria*, and fish exposed to methylmercury.

Improperly Stored Foods

Not all bacterial growth causes a food's surface to discolor or smell bad. For example, Larson and Johnson (1999) reported that botulinal toxin formation occurred before overt spoilage occurred in cubed, packaged melons. Similarly, Lubin and colleagues (1985) found that hard-cooked eggs that contained toxins did not always produce unacceptable odors or a change in appearance that was detected. When there is any doubt about the safety of fresh or leftover foods, for example, when refrigerated leftovers have been stored for 3 to 4 days, it is advisable to discard them safely, not to taste them.

Listeriosis, Those at High Risk, and High-Risk Foods

A recent quantitative risk assessment documents the importance of addressing risks associated with the widely occurring bacterium *Listeria monocytogenes* (HHS/USDA, 2003). Listeriosis (the most serious illness induced by this pathogen) occurs rarely (i.e., currently approximately 3.4 cases per million people annually). When it does occur, however, it can be life threatening. Two population groups (pregnant women and their fetuses, the elderly, and other individuals who have a pre-existing illness that reduces the effectiveness of their immune system) are especially susceptible to potentially life-threatening human illness from listeriosis. In healthy people, the microorganism usually causes only a noninvasive gastrointestinal illness, with symptoms that include fever, vomiting, and/or diarrhea (HHS/USDA, 2003).

Of the foodborne pathogens tracked by CDC, *Listeria monocytogenes* had the second highest case fatality rate (21 percent) and the highest hospitalization rate (90.5 percent). If a pregnant woman develops listeriosis, her fetus also becomes exposed. Fetal infection can lead to fetal death, premature birth, or neonatal illness and death. Other people with impaired T-cell immunity (immunocompromised patients and the elderly) also are especially vulnerable to the high lethality of listeriosis (Rocourt et al., 2003).

Most prenatal cases of listeriosis are reported in the third trimester (Slutsker and Schuchat, 1999). A few days after the onset of symptoms, a pregnant woman may abort the fetus or have a premature delivery (Gellin and Broome, 1989). Late in the pregnancy, listeriosis may result in stillbirth or birth of a critically ill newborn. Listeriosis in the first trimester may result in spontaneous abortion.

Foods that pose high risk for listeriosis have all the following properties: (1) relatively high rates of contamination with *L. monocytogenes*, (2) characteristics that support the growth of *L. monocytogenes* to high numbers when refrigerated, (3) ready-to-eat, and (4) commonly stored for extended periods (HHS/USDA, 2003). Two food categories—deli meats (excluding those that are very salty, such as some ham, or low in water activity, such as hard salami) and frankfurters that have not been reheated to a safe temperature—have been categorized as *very high risk* for listeriosis. According to the Quantitative Assessment (HHS/USDA, 2003), this risk designation is consistent with the need for immediate attention for reducing the incidence of foodborne listeriosis. Addressing this risk in dietary guidance would be consistent with the position of Medeiros and colleagues (2001a; 2001b) that food safety education programs ensure that messages are aimed at reducing the risk of the most prevalent and/or serious causes of foodborne illness.

A report from the International Life Sciences Institute (ILSI) Risk Science Institute Expert Panel (2004) recommends that high-risk individuals (i.e., the elderly, pregnant women, and most immunocompromised people) should be given specific information on high-risk foods that they should avoid and strategies to reduce their risk, such as thorough cooking, avoidance of cross-contamination, and short-term refrigerated storage of cooked, perishable foods.

Methylmercury in Fish

Methylmercury is a heavy metal toxin found in varying levels in different types of fish. This toxin can cause neurological harm to fetuses and young children, whose brains are still developing. Mahaffey and colleagues (2004), using blood methylmercury data and fish intake data from the 1999–2000 *National Health and Nutrition Examination Survey*, estimated *in utero* methylmercury concentrations of newborns. They estimated that more than 300,000 U.S. newborns each year may have been exposed to methylmercury concentrations higher than those considered to be without increased risk of adverse neurodevelopmental effects. The FDA released an advisory in March 2004 (U.S Food and Drug Administration, 2004) for women and young children, developed jointly with the Environmental Protection Agency, that provides guidance on how to receive the benefits of eating fish while being confident that exposure to the harmful effects of mercury is very low. The advisory warns against eating shark, swordfish, king mackerel, or tilefish because these fish contain high levels of

mercury. Instead, the advisory recommends that women eat up to 12 ounces per week of a variety of fish and shellfish that are lower in mercury (e.g., shrimp, canned light tuna, salmon, pollock, and catfish). Since albacore ("white") tuna is commonly eaten and has more mercury than canned light tuna, women are advised to limit their intake to 6 ounces of albacore tuna per week. The advisory calls for smaller portions of these fish for young children. Advice also is provided about fish from local waters.

Schober et al. (2003) found that measures of mercury exposure in women of childbearing age and in young children generally fall below levels of concern. They recommend that women who are pregnant or who intend to become pregnant follow Federal and state advisories on the consumption of fish. Because of wide variations in the concentrations of mercury in different kinds of fish and shellfish, it is possible to have the nutritional benefits of moderate fish consumption and avoid fish high in mercury (Schober, 2003).

Summary

Taking four basic food safety measures can help consumers protect against foodborne illness. These measures include cleaning hands, contact surfaces, and fruits and vegetables; separating raw, cooked, and ready-to-eat foods while shopping, preparing, or storing; cooking foods to a safe temperature; and chilling perishable foods promptly. In addition, avoiding higher risk foods (such as frankfurters that have not been reheated to a safe temperature) is an important protective measure, especially for high-risk groups (the very young, pregnant women, the elderly, and those who are immunocompromised).

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Section 10: Major Conclusions

Nutrient Adequacy

Question 1: What Nutrients Are Most Likely to Be Consumed by the General Public in Amounts Low Enough to Be of Concern?

Conclusion

Reported dietary intakes of the following nutrients are low enough to be of concern:

- For adults: vitamins A, C, and E, calcium, magnesium, potassium, and fiber
- For children: vitamin E, calcium, magnesium, potassium, and fiber

Efforts are warranted to promote increased dietary intakes of vitamin E, potassium, and fiber regardless of age; increased intakes of vitamins A and C, calcium, and magnesium by adults; and increased intakes of calcium and magnesium by children age 9 years and older. Efforts are especially warranted to improve the dietary intakes of adolescent females.

Question 2: What Dietary Pattern is Associated with Achieving Recommended Nutrient Intakes?

Conclusion

Two major aspects of the USDA dietary pattern contribute to meeting nutrient intake recommendations:

1. Consumption of foods from each of the basic food groups:

   - fruits
   - vegetables
   - grains
   - milk, yogurt, and cheese
   - meat, poultry, fish, dry beans, eggs, and nuts[1]

2. Consumption of a variety of food commodities within each of those food groups—since higher energy intake is strongly associated with greater variety and higher nutrient intake, attention also should be given to food group choices that maintain appropriate energy balance.

[1] Some patterns designed to meet nutrient intake recommendations divide this group into two groups: (1) meat, poultry, and fish and (2) seeds, dry peas and beans, and nuts.

Question 3: What Factors Related to Diet or Physical Activity May Help or Hinder Achieving Recommended Nutrient Intakes?

Conclusion

A sedentary lifestyle limits the amount of calories needed to maintain one's weight. Careful food selection is needed to meet recommended nutrient intakes within this calorie limit. Diets that include foods with a high nutrient content relative to calories are helpful in achieving recommended nutrient intakes without excess calories. Diets that include a large proportion of foods or beverages that are high in calories but low in nutrients are unlikely to meet recommended intakes for micronutrients and fiber, especially for sedentary individuals.

Question 4: How Can the Flexibility of Food Patterns be Increased?

Conclusion

By careful planning that considers the relative nutrient content of different foods, substitutions can be made to a food intake pattern to achieve recommended nutrient intakes.

Question 5: Are Special Nutrient Recommendations Needed for Certain Subgroups?

Conclusion

Special nutrient recommendations are warranted for the following subgroups and nutrients:

- Adolescent females and women of childbearing age—iron and folic acid
- Persons over age 50—vitamin B^{12}
- The elderly, persons with dark skin, and persons exposed to insufficient ultraviolet band (UVB) radiation—vitamin D

A conclusion and rationale specific to each group and nutrient can be found in Part D, Section 1, Question 5.

Energy

Question 1: How Is Physical Activity Related to Body Weight and Other Nutrition-Related Aspects of Health?

Conclusion

Regular physical activity is essential to the maintenance of a healthy weight and reduces risk for the development of a number of chronic diseases. At least 30 minutes of moderate physical activity on most days provides important health benefits in adults. More than 30 minutes of moderate to vigorous physical activity on most days provides added health benefits. Many adults may need up to 60 minutes of moderate to vigorous physical activity on most days to prevent unhealthy weight gain.

Vigorous physical activity (e.g., jogging or other aerobic exercise) provides greater benefits for physical fitness than does moderate physical activity and burns calories more rapidly per unit of time.

Exercise that loads the skeleton has potential to reduce the risk of osteoporosis by increasing peak bone mass during growth, maintaining peak bone mass during adulthood, and reducing the rate of bone loss during aging.

Resistance exercise training increases muscular strength and endurance and maintains or increases lean body weight. These benefits are seen in adolescents, adults, and older adults who perform 8 to 10 resistance exercises 2 or more days per week.

Children and adolescents need at least 60 minutes of moderate to vigorous physical activity on most days for maintenance of good health and fitness and for healthy weight during growth. Reducing sedentary behaviors, including television- and video-viewing time, appears to be an effective way to treat and prevent overweight among children and adolescents.

Question 2: How Much Physical Activity is Needed to Avoid Weight Regain in Weight-Reduced Persons?

Conclusion

Although the contribution of physical activity to weight loss usually is modest, acquiring a routine of regular physical activity will help an adult to maintain a stable body weight after successful weight loss. The amount of physical activity that weight-reduced adults need to avoid weight regain is estimated to be from 60 to 90 minutes daily at moderate intensity.

Question 3: What Are the Optimal Proportions of Dietary Fat and Carbohydrate to Maintain Body Mass Index (BMI) and to Achieve Long-Term Weight Loss?

Conclusion

Weight maintenance depends on a balance of energy intake and energy expenditure, regardless of the proportions of fat, carbohydrate, and protein in the diet. Weight loss occurs when energy intake is less than energy expenditure, also regardless of the proportions of fat, carbohydrate, and protein in the diet. For adults, well-planned weight-loss diets that are consistent with the Accepted Macronutrient Distribution Ranges (IOM, 2002) for fat, carbohydrate, and protein can be safe and efficacious over the long term. The recommended ranges for fat calories (20 to 35 percent of total calories), carbohydrate calories (45 to 65 percent of total calories), and protein calories (10 to 35 percent of total calories) provide sufficient flexibility to accommodate weight maintenance for a wide variety of body sizes and food preferences.

Question 4: What Is the Relationship Between the Consumption of Energy-Dense Foods and BMI?

Conclusion

Available data are insufficient to determine the contribution of energy-dense foods to unhealthy weight gain and obesity. However, consuming energy-dense meals may contribute to excessive caloric intake. Conversely, eating foods of low energy density may be a helpful strategy to reduce energy intake when trying to maintain or lose weight.

Question 5: What Is the Relationship Between Portion Size and Energy Intake?

Conclusion

The amount of food offered to a person influences how much he or she eats; and, in general, more calories are consumed when a large portion is served rather than a small one. Thus, steps are warranted for consumers to limit the portion size they take or serve to others, especially for foods that are energy dense.

Fats

Question 1: What Are the Relationships Between Total Fat Intake and Health?

Conclusion

At low intakes of fat (less than 20 percent of energy) and high intakes of carbohydrates (more than 65 percent of energy), risk increases for inadequate intakes of vitamin E, α-linolenic acid, and linoleic acid and for adverse changes in high density lipoprotein (HDL) cholesterol and triglycerides. At high intakes of fat (more than 35 percent of energy), the risk increases for obesity and coronary heart disease (CHD). This is because fat intakes that exceed 35 percent of energy are associated with both increased calorie and saturated fat intakes. Total fat intake of 20 to 35 percent of calories is recommended for adults and 25 to 35 percent for children age 4 to 18 years. A fat intake of 30 to 35 percent of calories is recommended for children age 2 to 3 years.

Question 2: What Are the Relationships Between Saturated Fat Intake and Health?

Conclusion

The relationship between saturated fat intake and low density lipoprotein (LDL) cholesterol is direct and progressive, increasing the risk of cardiovascular disease (CVD). Thus, saturated fat consumption by adults should be as low as possible while consuming a diet that provides 20 to 35 percent calories from fat and meets recommendations for α-linolenic acid and linoleic acid. In particular,

- For adults with LDL cholesterol below 130 mg/dL, less than 10 percent of calories from saturated fatty acids is recommended.
- For adults with an elevated LDL cholesterol (≥130 mg/dL), less than 7 percent of calories from saturated fatty acids is recommended.[2]

Question 3: What Are the Relationships Between *trans* Fat Intake and Health?

Conclusion

The relationship between *trans* fatty acid intake and LDL cholesterol is direct and progressive, increasing the risk of CHD. *Trans* fatty acid consumption by all population groups should be kept as low as possible, which is about 1 percent of energy intake or less.

Question 4: What Is the Relationship Between Cholesterol Intake and CVD?

Conclusion

The relationship between cholesterol intake and LDL cholesterol concentrations is direct and progressive, increasing the risk of CHD. Thus, cholesterol intake should be kept as low as possible within a nutritionally adequate diet. In particular,

- For adults with an LDL cholesterol < 130 mg/dL, less than 300 mg of dietary cholesterol per day is recommended.
- For adults with an elevated LDL cholesterol (≥130 mg/dL), less than 200 mg of dietary cholesterol per day is recommended.

Question 5: What Are the Relationships Between n-6 Polyunsaturated Fatty Acid (PUFA) Intake and Health?

Conclusion

An n-6 PUFA intake between 5 to 10 percent of energy may confer beneficial effects on coronary artery disease mortality.

Question 6: What Are the Relationships Between n-3 Fatty Acid Intake and Health?

Conclusion

An α-linolenic acid intake between 0.6 to 1.2 percent of calories will meet requirements for this fatty acid and may afford some protection against CVD outcomes.

The consumption of two servings (approximately 8 ounces) per week of fish high in eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) is associated with reduced risk of both sudden death and CHD death in adults. To benefit from the potential cardioprotective effects of EPA and DHA, the weekly consumption of two servings of fish, particularly fish rich in EPA and DHA, is suggested. Other sources of EPA and DHA may provide similar benefits; however, further research is warranted.

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[2] For persons with known heart disease, medical advice and the use of ATP III Panel Guidelines are indicated.

Question 7: What Are the Relationships Between MUFA Intake and Health?

Conclusion

There is an inverse relationship between the intake of monounsaturated fatty acids (MUFAs) and the total cholesterol (TC) to HDL cholesterol concentration ratio. If equal amounts of MUFAs are substituted for saturated fatty acids, LDL cholesterol decreases.

Carbohydrates

Question 1: What Is the Relationship Between Intake of Carbohydrates and Dental Caries?

Conclusion

The intake of carbohydrates (including sucrose, glucose, fructose, lactose, and starch) contributes to dental caries by providing substrate for bacterial fermentation in the mouth. Drinking fluoridated water and/or using fluoride-containing dental hygiene products help reduce the risk of dental caries. A combined approach of reducing the frequency and duration of exposure to fermentable carbohydrates and optimizing oral hygiene practices is the most effective way to reduce caries incidence.

Question 2: What Is the Relationship Between Carbohydrate Intake and Incidence of Diabetes Mellitus?

Conclusion

A potential health concern for foods that raise blood glucose levels and initiate an insulin response is that they may eventually lead to diabetes. Current evidence suggests that there is no relationship between total carbohydrate intake (minus fiber) and the incidence of either type 1 or type 2 diabetes. The intake of fiber-containing foods is associated with a decreased risk of type 2 diabetes in a number of epidemiological studies.

Question 3: What Is the Utility of the Glycemic Index/Glycemic Load for Providing Dietary Guidance for Americans?

Conclusion

Current evidence suggests that glycemic index and/or glycemic load are of little utility for providing dietary guidance for Americans.

Question 4: What Is the Significance of Added Sugar Intake to Human Health?

Conclusion

Compared with individuals who consume small amounts of foods and beverages that are high in added sugars, those who consume large amounts tend to consume more calories but smaller amounts of micronutrients. Although more research is needed, available prospective studies suggest a positive association between the consumption of sugar-sweetened beverages and weight gain. A reduced intake of added sugars (especially sugar-sweetened beverages) can lower calorie intake, and may be helpful in achieving recommended intakes of nutrients and in weight control.

Question 5: What Are the Major Health Benefits of Fiber-Containing Foods?

Conclusion

Diets rich in dietary fiber have a number of important health benefits including helping to promote healthy laxation, reducing the risk of type 2 diabetes, decreasing the risk of CHD and maintaining a healthy body weight. Prospective cohort studies show that decreased risk of heart disease is associated with the intake of 14 g of dietary fiber per 1,000 calories.

Food Groups

Question 1: What Are the Relationships Between Fruit and Vegetable Intake and Health?

Conclusion

Greater consumption of fruits and vegetables (5 to 13 servings or 2½ to 6½ cups per day depending on calorie needs[3]) is associated with a reduced risk of stroke and perhaps other CVDs, with a reduced risk of cancers in certain sites (oral cavity and pharynx, larynx, lung, esophagus, stomach, and colon-rectum), and with a reduced risk of type 2 diabetes (vegetables more than fruit). Moreover, increased consumption of fruits and vegetables may be a useful component of programs designed to achieve and sustain weight loss.

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[3] See Tables D1-13 and D1-15 for information on children age 2 to 3.

Question 2: What Are the Relationships Between Whole-Grain Intake and Health?

Conclusion

Consuming at least three servings (equivalent to 3 ounces) of whole grains per day can reduce the risk of diabetes and CHD and help with weight maintenance. Thus, daily intake of 3 ounces of whole grains per day is recommended, preferably by substituting whole grains for refined grains.

Question 3: What Are the Relationships Between Milk Product Intake and Health?

Conclusion

Consuming three servings (equivalent to 3 cups) of milk and milk products each day can reduce the risk of low bone mass and contribute important amounts of many nutrients. Furthermore, this amount of milk product consumption may have additional health benefits and is not associated with increased body weight. Therefore, the intake of three cups of milk products per day is recommended.

Fluids and Electrolytes

Question 1: What Amount of Fluid Is Recommended for Health?

Conclusion

The combination of thirst and usual drinking behavior, especially the consumption of fluids with meals, is sufficient to maintain normal hydration. Healthy individuals who have routine access to fluids and who are not exposed to heat stress consume adequate water to meet their needs. Purposeful drinking is warranted for individuals who are exposed to heat stress or who perform sustained vigorous activity.

Question 2: What Are the Effects of Salt (Sodium Chloride) Intake on Health?

Conclusion

The relationship between salt (sodium chloride) intake and blood pressure is direct and progressive without an apparent threshold. Hence, individuals should reduce their salt intake as much as possible. In view of the currently high levels of salt intake, a daily sodium intake of less than 2,300 mg is recommended. Many persons will benefit from further reductions in salt intake, including hypertensive individuals, blacks, and middle-aged and older adults. Individuals should concurrently increase their consumption of potassium because a diet rich in potassium blunts the effects of salt on blood pressure.

Question 3: What Are the Effects of Potassium Intake on Health?

Conclusion

Diets rich in potassium can lower blood pressure and lessen the adverse effects of salt on blood pressure, may reduce the risk of developing kidney stones, and possibly decrease bone loss. In view of the health benefits of potassium and its relatively low intake by the general population, a daily potassium intake of at least 4,700 mg is recommended. Blacks are especially likely to benefit from an increased intake of potassium.

Ethanol

Question 1: Among Persons Who Consume Four or Fewer Alcoholic Beverages per Day, What Is the Dose-Response Relationship Between Alcohol Intake and Health?

Conclusion

1. In middle-aged and older adults, a daily intake of one to two alcoholic beverages is associated with the lowest all-cause mortality.
2. Compared with nondrinkers, adults who consume one to two alcoholic beverages per day appear to have lower risk of CHD.
3. Compared with nondrinkers, women who consume one alcoholic beverage per day appear to have a slightly higher risk of breast cancer.
4. Relationships of alcohol consumption with major causes of death do not differ for middle-aged and elderly Americans. Among younger people, however, alcohol consumption appears to provide little, if any, health benefit; alcohol use among young adults is associated with a higher risk of traumatic injury and death.

Question 2: What Is the Relationship Between Consuming Four or Fewer Alcoholic Beverages Daily and Macronutrient Profiles, Micronutrient Profiles, and Overall Diet Quality?

Conclusion

A daily intake of one to two alcoholic beverages is not associated with inadequate intake of macronutrients or micronutrients, or with overall dietary quality.

Food Safety

Question 1: What Behaviors Are Most Likely to Prevent Food Safety Problems?

Conclusion

The behaviors in the home that are most likely to prevent a problem with foodborne illnesses are

- Cleaning hands, contact surfaces, and fruits and vegetables (but not meat and poultry, which should not be washed)
- Separating raw, cooked, and ready-to-eat foods while shopping, preparing, or storing
- Cooking foods to a safe temperature
- Chilling (refrigerating) perishable foods promptly

Question 2: What Topics, if Any, Need Attention Even Though They Are Not an Integral Part of the "Fightbac!" Campaign?

Conclusion

Avoiding higher risk foods is an important protective measure (e.g., deli meats and frankfurters that have not been reheated to a safe temperature may contain *Listeria*). This is especially important for high-risk groups (the very young, pregnant women, elderly, and those who are immunocompromised).

Part E: Translating the Science into Dietary Guidance

The purpose of this part of the report is to identify content needed to translate the findings of the Dietary Guidelines Advisory Committee (the Committee) into policy and dietary guidance for consumers. This information should be useful to nutrition-related program providers, healthcare providers, and educators, as well as to the groups charged with the responsibility of producing policy statements and the 2005 edition of the *Dietary Guidelines for Americans.* The Committee provides specific recommendations for the content of main messages and supporting details, but we leave the wording of consumer documents to communication experts.

Good nutrition is vital to good health—both in the present and the distant future. Good nutrition is absolutely essential for the healthy growth and development of children and adolescents. A basic premise of the Committee is that nutrient needs should be met primarily through consuming foods. Foods provide an array of nutrients and other compounds that may have beneficial effects on health. In some cases, fortified foods may be useful sources of one or more nutrients that otherwise might be consumed in less than recommended amounts. Nutrient supplements cannot replace a healthful diet. Supplements are useful when they fill a specific identified nutrient gap that cannot or is not otherwise being met by the individual's intake of food. Individuals who are already consuming the recommended amount of a nutrient will not achieve any recognized health benefit if they also take the nutrient as a supplement. In fact, in some cases, supplements and fortified foods may cause intakes to exceed the Tolerable Upper Intake Level for nutrients.

In brief, the Committee's findings support the development of *Dietary Guidelines* that convey the following messages:

- Consume a variety of foods within and among the basic food groups while staying within energy needs.
- Control calorie intake to manage body weight.
- Be physically active every day.
- Increase daily intake of fruits and vegetables, whole grains, and nonfat or low-fat milk and milk products.
- Choose fats wisely for good health.
- Choose carbohydrates wisely for good health.
- Choose and prepare foods with little salt.
- If you drink alcoholic beverages, do so in moderation.
- Keep food safe to eat.

All these topics are important to promote day-to-day health and to reduce the risk for major chronic diseases. The topics are not listed in order of priority. In fact, they are closely interrelated. Consuming a variety of foods from the basic food groups and controlling calorie intake are two major themes—themes that are intertwined. To achieve weight control, for example, guidance to increase one's intake of certain food groups must go hand in hand with guidance to decrease intake of added sugars and solid fats. At the same time, being physically active increases energy expenditure and makes it easier to meet recommended intakes for nutrients and to control weight. The Committee believes these messages should be conveyed in *Nutrition and Your Health: Dietary Guidelines for Americans, 2005.*

The list of major messages includes a major departure from previous editions of *Dietary Guidelines for Americans* in that it does not include a message specifically directed toward sugars. This omission does not mean that the current Committee views the topic of sugars as unimportant. On the contrary, the Committee provides a strong rationale for limiting one's intake of added sugars. The Committee's intent is to make this point clearly under the new topic "Choosing Carbohydrates Wisely for Good Health" and under the first and second topics that address energy needs and controlling calorie intake, respectively.

Consume a Variety of Foods Within and Among the Basic Food Groups While Staying Within Energy Needs

Overview

Many Americans consume more calories than they need without meeting recommended intakes for a number of nutrients. This circumstance means that most people need to choose meals and snacks that are high in nutrients but low to moderate in energy content; that is, meeting nutrient recommendations must go hand in hand with keeping calories under control. Doing both offers important benefits—normal growth and development of children, health promotion for people of all ages, and reduction of risk for a number of chronic diseases that are major public health problems.

Dietary data suggest that, in general,

- Adults do not consume enough vitamins A, C, and E; calcium; magnesium; potassium; and fiber.[1]
- Children do not consume enough vitamin E, calcium, magnesium, potassium, and fiber.

At the same time, in general, Americans consume too many calories and too much saturated and *trans* fat, cholesterol, added sugars, and salt.

Key Messages

- Eating a variety of food within and among the basic food groups helps one achieve recommended nutrient intakes while maintaining appropriate energy intake.
- Adults who consume the amounts of fruits and vegetables, whole grains, and nonfat or low-fat milk and milk products that are recommended in the U.S. Department of Agriculture (USDA) food intake pattern (see Table D1-13 and the Dietary Approaches to Stop Hypertension (DASH) diet, Table D1-18) will achieve the levels of intake of these foods that are associated with a reduced risk of chronic disease.
- Diets can be planned to meet recommended nutrient intakes while considering the food preferences of different racial/ethnic groups, vegetarians, and others.
- A few special nutrient recommendations apply to the elderly, women in the childbearing years, and groups susceptible to vitamin D insufficiency.
- Combining a physically active lifestyle with an eating pattern that features foods high in nutrient density helps to achieve recommended nutrient intakes without excess calorie intake.

Additional Important Information

Meeting Recommended Intakes Within Energy Needs

- It is essential to convey the concept "a variety of foods from within each of the basic food groups" accurately to consumers. The food groups consist of fruits, vegetables, grains, milk, and meat and beans. The term ***foods*** refers to agricultural commodities such as wheat, corn, green beans, oranges, beef, eggs, fish, poultry, milk, and cheese. A meal that includes salmon, brown rice, spinach, sliced tomatoes, and nonfat milk includes five different food commodities. Bread, pasta, crackers, bulgar, and wheat cereal represent only one food commodity (wheat). Consuming different forms of the same commodity has not been associated with improved nutrient intake.
- The recommended nutrient intakes that are based on Dietary Reference Intakes are listed in Table D1-1. The calorie level that is generally appropriate for each age/gender group at a specified physical activity level is shown in Table D3-1.
- The use of the revised USDA food intake pattern is one method to plan to meet recommended nutrient intakes considering age, gender, and physical activity level. The food intake pattern in Table D1-13 includes suggested amounts to eat from each of the basic food groups and subgroups. Oils and *trans* fat free soft margarines also are included in the food intake pattern to provide essential fatty acids and vitamin E.
- When using the food intake pattern to plan diets, one must pay close attention to the forms of food described in footnote 1 to Table D1-13 and to Table D1-14, which provides additional information about discretionary calories. The pattern assumes that the meats and poultry are

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[1] Folate also was identified as a shortfall nutrient by the studies cited in Part D; however, the data used for these studies were collected prior to the mandatory fortification of enriched grains with folate. See further discussion in Part D, Section 1, "Aiming To Meet Recommended Intakes of Nutrients."

in their lowest fat form, the milk is nonfat, and the foods from all of the food groups contain no added sugars or fats. These are not the forms of food eaten by most Americans. Discretionary calorie values listed in Table D1-13 and D1-14 are the maximum amounts that can be accommodated at each calorie level. Discretionary calories are available to use for increasing variety, for example, having more fruits or vegetables or having medium-fat meat or cheese sometimes—or low-fat or whole milk, sweetened low-fat yogurt, sweetened cereal, or cake. Most people will exceed calorie recommendations if they consistently choose medium-fat meat and full-fat milk products in the amounts specified in the table—even if they do not have dessert, sweetened beverages, or alcoholic beverages.

- Eating the amounts of foods from each food group listed in the food intake pattern table each day (or averaged over a week in the case of vegetable subgroups) will enable most people to meet their recommended nutrient intakes at a calorie level that does not exceed their energy needs. Eating in accordance with the food intake pattern also will keep intakes of saturated fat, total fat, and cholesterol within the limits recommended under "Choosing Fats Wisely for Good Health."
- The food intake pattern that is designed to meet currently recommended nutrient intakes differs in important ways from commonly consumed food patterns. In general, they include
  - **More** dark green vegetables, bright orange vegetables, legumes, fruits, whole grains, and milk
  - **Less** enriched grains, total fats (especially solid fats), added sugars, and calories
- Americans need to increase their consumption of vitamin E- (α-tocopherol-) rich foods while decreasing their intake of foods high in energy but low in nutrients. The USDA food intake pattern does not provide for meeting the recommended intake of vitamin E unless vitamin E-rich sources are selected. Foods that can help increase vitamin E intake are listed in Table D1-8a, along with their calorie content. Breakfast cereal that is fortified with vitamin E is an option for individuals seeking to increase their vitamin E intake while consuming a low-fat diet.
- Most Americans of all ages also need to increase their fiber intake. Diets rich in fiber help reduce the risk of coronary heart disease and promote healthy laxation. Table D1-11a identifies foods that help increase fiber intake. Substituting whole grains for refined grains is a good way to increase fiber intake without increasing energy intake.
- Most Americans of all ages need to increase their potassium intake. Diets rich in potassium can lower blood pressure, lessen the adverse effects of salt on blood pressure, may reduce the risk of developing kidney stones, and possibly decrease bone loss. Blacks have a lower intake of potassium than do whites and a higher prevalence of elevated blood pressure and salt sensitivity. Thus, this subgroup of the population especially would benefit from an increased intake of potassium. Table D1-10a identifies foods that can help increase potassium intake and provides information about their calorie content.
- Many Americans need to increase their intake of vitamins A and C and/or magnesium. Tables D1-5a through D1-7a identify foods that help increase the intake of each of these nutrients, along with their calorie content.

Flexibility

A number of approaches can be used to increase the flexibility of the meal pattern while still meeting the recommended intake values. Such flexibility is to be encouraged to accommodate individual preferences, cultural preferences, cost, and availability.

- ***Vegetarian Choices.*** Vegetarians can achieve recommended nutrient intakes through careful selection of foods, especially if they give special attention to their intakes of protein, iron, vitamin B_{12}, and calcium and vitamin D (if they avoid milk products). One way for a lacto-ovo vegetarian who needs 2,200 kcal to make daily selections from the meat and beans group would be to eat 1 egg, 1.5 ounces of nuts, and 2/3 cup legumes instead of 6 ounces of meat, poultry, and/or fish (further information is available in Appendix 2).
- ***Enriched Grain Substitutions.*** Whole grains can be substituted for enriched grains on an ounce-for-ounce basis. They are comparable in energy content and will meet nutrient recommendations in the food intake pattern. (Further information is available in Appendix G-2.)

- ***Legume Substitutions.*** For people who do not like legumes, several other food choices can be substituted in the food intake pattern and still meet nutrient recommendations. (See Appendix G-2.)
- ***Substitutions for Milk and Milk Products.*** Since milk and milk products provide more than 70 percent of the calcium consumed by Americans, guidance on other choices of dietary calcium is needed for those who choose not to consume the recommended amount of milk products. (Tables D1-9a and D1-19 include information on calcium content and bioavailability from a variety of foods.) Those who avoid milk may need to choose rich sources of the nutrients shown in Table D1-20 as well. Foods that can help increase intake of some of the nutrients provided by milk appear in Tables D1-5a, D1-7a, D1-9a, and D1-10a.

  Those who avoid milk because of its lactose content may obtain all the nutrients provided by the milk group by using lactose-reduced or low-lactose milk products, taking small servings of milk several times a day, taking the enzyme lactase before consuming milk products, or eating other calcium-rich foods such as calcium-fortified orange juice, fortified soymilk products, and broccoli. For additional information, see Tables D1-9a through D1-19 and *http://digestive.niddk.nih.gov/ddiseases/pubs/lactoseintolerance/index.htm.*

Meeting Nutrient Needs of Special Groups

- Women of childbearing age can reduce the risk of iron deficiency by eating foods high in iron (preferably meat, poultry, fish, and shellfish) and/or consuming iron-rich plant foods, such as iron-fortified breakfast cereals, with a food rich in vitamin C (e.g., orange juice). Table D1-22a lists foods that can help increase iron intake and gives their calorie content.
- To reduce the risk of a pregnancy being affected by a neural tube defect, daily intake of 400 μg of synthetic folic acid (from supplements or fortified food) is recommended for women who are capable of becoming pregnant and those in the first trimester of pregnancy.
- Because many persons over age 50 have reduced ability to absorb naturally occurring vitamin B_{12}, consuming vitamin B_{12} in its crystalline form is recommended for this age group. The goal for those over age 50 is to eat foods fortified with vitamin B_{12}, such as fortified breakfast cereals, or to take vitamin B_{12} supplements to achieve a B_{12} intake of at least 2.4 μg per day. (This equals about 40 percent of the Daily Value expressed on food labels.)
- The elderly, persons with dark skin, and persons exposed to insufficient ultraviolet band (UVB) radiation are at risk of being unable to maintain vitamin D status. Persons in these groups may need substantially more than the 1997 Adequate Intake (AI) for vitamin D from vitamin D-fortified foods and/or vitamin D supplements. Three cups of vitamin D-fortified milk (300 IU), one cup of vitamin D-fortified orange juice (100 IU), and 600 IU of supplemental vitamin D would provide 1,000 IU of vitamin D daily.

Nutrient Density

- Nutrient-dense foods are those that provide substantial amounts of vitamins and minerals and relatively fewer calories. Foods that are low in nutrient density are foods that supply calories but relatively small amounts of micronutrients (sometimes none at all).
- The greater the consumption of foods or beverages that are low in nutrient density, the more difficult it is to consume enough nutrients without gaining weight, especially for sedentary individuals.
- The consumption of added sugars, solid fats, and alcohol provides calories while providing little, if any, of the essential nutrients.

Control Calorie Intake to Manage Body Weight

Overview

The prevalence of obesity has doubled in the past two decades. Nearly one-third of adults have a body mass index (BMI) in the obese range of 30 or greater. The prevalence of overweight among both children and adolescents has increased substantially as well. A high prevalence of overweight and obesity among adults is of great public health concern because excess body fat leads to a much higher risk for premature death, diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, stroke, gall bladder disease, respiratory dysfunction, gout, osteoarthritis, and certain kinds of cancers. Ideally, the goal for adults is to achieve and maintain a BMI in the healthy weight range. However, even modest weight loss (e.g., 10 pounds) has health

benefits, and the prevention of further weight gain is very important. For overweight children and adolescents, the goal is to slow the rate of weight gain to achieve healthy growth. Maintaining a healthy weight throughout childhood will reduce an individual's risk of becoming an overweight or obese adult. Eating fewer calories is a key method of controlling body weight. Increasing physical activity also is very helpful in weight control, but because physical activity has additional beneficial effects on nutrition and health, it is covered separately. (See "Be Physically Active Every Day.")

Key Messages

- Persons who follow typical American eating and activity patterns have used up all their discretionary calories and are likely to be consuming diets well in excess of their energy requirements for their age, gender, and physical activity level. To stem the obesity epidemic, most Americans need to reduce the amount of calories they consume. When it comes to weight control, calories *do* count—not the proportions of carbohydrate, fat, and protein in the diet.
- Since many adults gain weight slowly over time, even small decreases in calorie intake can help avoid weight gain. Decreasing intake or increasing expenditure by 50 to 100 calories per day would enable many adults to maintain their weight rather than continuing to gain weight each year. For children who are gaining excess fat, a similar small decrease in energy intake can reduce the rate at which they gain weight so as they age they will grow into a healthy weight.
- Focusing on the prevention of overweight is critical because the behaviors required to lose weight are more challenging than the behaviors required to prevent weight gain. For most people, a reduction of 50 to 100 calories per day will prevent weight gain, but a reduction of 500 calories or more per day is a common goal in weight loss programs. Similarly, 30 to 60 minutes of moderate physical activity per day is recommended to prevent weight gain, but up to 60 to 90 minutes of physical activity per day is recommended to sustain weight loss among persons who have been overweight. (See "Being Physically Active Every Day.")
- Weight maintenance depends on balancing energy consumed and energy expended. Weight loss requires taking in fewer calories than expended. Small decreases in calorie intake can lead to big benefits if sustained over time, especially if accompanied by increased physical activity. (See Table E-1 for the essential elements of weight loss.)
- Calories come from fat, carbohydrate, protein, and alcohol. The healthiest way to reduce calorie intake is to reduce one's intake of added sugars, solid fat, and alcohol—they all provide calories, but they do not provide essential nutrients. Table E-2 gives some examples of how calories can be decreased by choosing foods that are lower in saturated fats. Table E-3 gives examples of how calories can be decreased by decreasing alcoholic beverage intake.
- When making changes to improve nutrient intake, one needs to take care to make substitutions to avoid excessive calorie intake. For example, foods such as fruits, vegetables, and whole grains—all of which provide fiber—might be eaten in place of more refined foods such as fruit drinks and refined grain products.
- Monitoring body weight regularly is a useful strategy for identifying weight changes and the need to decrease one's energy intake, increase physical activity, or both. Such changes are fundamental to controlling one's weight.
- Reduced calorie diets that provide fat, carbohydrate, and protein within the recommended ranges can be safe and efficacious for weight loss. Diets that provide very low or very high amounts of protein, carbohydrate, or fat are likely to provide low amounts of a number of nutrients and are not advisable for long-term use.

Additional Important Information

- Eating foods that are high in calories and low in volume may make it hard to avoid excessive calorie intake. Eating foods that are low in calories and high in volume (such as many kinds of vegetables and fruits and some soups) may be a useful strategy to reduce energy intake.
- Controlling portion sizes helps limit calorie intake, especially when eating energy-dense foods (foods that are high in calories for a given amount). Table E-4 provides information on how portion sizes have grown over the past 20 years.
- Diets rich in whole grains, fruits, and vegetables may help with weight maintenance.
- It is unclear whether consuming milk products helps control body weight, but consuming three servings of milk products daily is not associated with increased body weight.

- Table E-5 gives examples of some simple ways to cut calories from your diet.
- Use the BMI chart (Figure E-1) to determine your BMI using your height and weight. If your BMI does not fall into the "Healthy Weight" section, set your weight goal as a weight corresponding to your height and "Healthy Weight" on the BMI chart.
- Table D3-1 will help you estimate your current energy requirements according to your gender, age, and physical activity level so that you can know what your caloric intake limit is to maintain a healthy weight.

Be Physically Active Every Day

Overview

Americans tend to be relatively inactive. In 2002, 38 percent of adult Americans engaged in no leisure-time physical activity, and in 1999, 43 percent of students in grades 9 through 12 viewed television nearly 3 hours per day. Regular physical activity and physical fitness make a big contribution to one's day-to-day health and sense of well-being. Lack of physical activity puts many people at risk. In particular, a sedentary lifestyle poses risks for coronary artery disease, hypertension, type 2 diabetes, overweight and obesity, osteoporosis, certain types of cancer, anxiety, depression, decreased health-related quality of life, and decreased cardiorespiratory, metabolic, and musculoskeletal fitness. All-cause mortality rates are lower in physically active than in sedentary persons.

Key Messages

- At least thirty minutes of moderate physical activity on most days provide important health benefits in adults in part by reducing the risk of chronic disease. More than 30 minutes of moderate to vigorous physical activity on most days provide even more health benefits.
- Participating in up to 60 minutes of moderate to vigorous physical activity on most days is recommended to prevent unhealthy weight gain among adults. After losing weight, adults who obtain 60 to 90 minutes of moderate physical activity daily are more successful at maintaining their reduced weight than those who rely only on limiting calorie intake.
- The recommendation for children and adolescents is at least 60 minutes of moderate to vigorous physical activity on most days to maintain good health and fitness and for healthy weight during growth. Increasing physical activity can lower the BMI of overweight children.
- Regular physical activity is essential to the maintenance of a healthy weight for children and adults and a useful component of weight-control programs. Physical activity increases total energy expenditure and thus the number of calories needed in a day. Energy expenditure increases with increases in both the duration and the intensity of physical activity. Table E-6 provides examples of physical activities and the calories expended by performing these physical activities.
- Physical fitness requires regular physical activity that involves cardiovascular conditioning, stretching exercises to enhance flexibility, and weight work or calisthenics to develop strength and muscle endurance.
- Vigorous-intensity physical activity (e.g., jogging or other aerobic exercise) provides greater benefits for physical fitness than moderate physical activity, and it burns more calories per unit time.
- During leisure time, it is advisable for all individuals to limit sedentary behaviors, such as television watching and video viewing, and replace them with activities that require more movement. Engaging in physical activity will increase a person's caloric requirement for weight maintenance. Therefore, a person who engages in regular physical activity may have more discretionary calories available to him or her than a sedentary individual.

Additional Important Information

- Activity counted toward the 30 minutes should not include usual activities at work or at home.
- The physical activity counted may include short bouts (e.g., 10-minute bouts) of moderate activity. The accumulated total is what is important—both for health and for burning calories. Setting aside 30 to 60 consecutive minutes for planned exercise is one way to obtain physical activity, but it is not necessary. Physical activity can be accumulated through three to six 10-minute bouts over the course of a day. The *accumulated total* is what is important—both for health and for burning calories.
- The body adapts to physical activity by building muscle and by increasing the maximum amount

of work than can be done and the use of oxygen. Regular aerobic exercise improves the cardiovascular system.

- Two steps that help avoid dehydration during prolonged physical activity in conditions of heat stress, whether for work or leisure are (1) consuming fluid regularly during the activity and (2) drinking several glasses of water or other fluid after the physical activity is completed.
- Most persons can safely increase their physical activity without consulting a healthcare provider. However, it is advisable for men over age 40, women over age 50, and those with a personal history of chronic diseases such as heart disease or diabetes to consult with a healthcare provider before starting an exercise program.
- Resistance exercise (such as weight training, using weight machines, and resistance band workouts) increases muscular strength and endurance and maintains or increases lean body weight. These benefits are seen in adolescents, adults, and older adults who perform 8 to 10 resistance exercises 2 or more days per week.
- Exercise that loads the skeleton has the potential to reduce the risk of osteoporosis by increasing peak bone mass during growth, maintaining peak bone mass during adulthood, and reducing the rate of bone loss during aging. Regular exercise can help prevent falls.

Increase Daily Intake of Fruits and Vegetables, Whole Grains, and Nonfat Or Low-Fat Milk and Milk Products

Overview

Increased intakes of fruits, vegetables, whole grains, and milk products are likely to have important health benefits for Americans. Compared with the many persons who consume only small amounts of fruits and vegetables, those who eat more generous amounts are likely to have reduced risk of chronic diseases, including stroke and perhaps other cardiovascular diseases, type 2 diabetes, and cancers in certain sites (oral cavity and pharynx, larynx, lung, esophagus, stomach, and colon-rectum). Diets rich in dietary fiber and in whole grains can reduce the risk of coronary heart disease. Diets rich in milk and milk products can reduce the risk of low bone mass throughout the life cycle, but many Americans have low intakes of milk products. The consumption of milk products is especially important for children and adolescents who are building their peak bone mass and developing lifelong habits.

Key Messages

- Fruits, vegetables, whole grains, and milk products are all important to a healthy diet and are good sources of the shortfall nutrients.
- A range of 5 to 13 servings (2½ to 6½ cups) of fruits and vegetables each day is recommended for daily energy intakes of 1,200 to 3,200 calories.[2] For a 2,000-calorie daily energy intake, 9 servings (4½ cups) are recommended, with increases or decreases depending on energy intake. Table E-7 provides the daily amounts of fruits and vegetables by calorie level.
- One goal is to consume a *variety* of fruits and vegetables each day. Over a week, eating vegetables from all five vegetable subgroups (dark green, bright yellow, legumes, starchy vegetables, and other vegetables) is recommended. For persons who require 2,000 calories daily to meet their energy needs, the recommended combined intake is 4½ cups (or the equivalent) of fruits and vegetables each day. Greater amounts are recommended for those with higher calorie requirements, and somewhat smaller amounts are recommended for those with lower calorie requirements. Table E-8 provides a list of fruits and vegetables that are the best sources of vitamins A and C, folate, and potassium. Table E-9 provides recommendations for ways to increase fruit and vegetable intake.
- The goal for whole-grain intake is at least three servings (approximately 3 ounces) per day, preferably by eating whole grains in place of refined grains. Table E-10 lists the whole grains that are widely available in the United States.
- For people who require 1,600 kcal per day or more, the goal for milk and milk products is three servings (3 cups) of nonfat or low-fat milk or milk products or the equivalent per day. The goal is 2 cups per day for those with lower calorie needs. Table E-11 provides recommendations for ways to increase milk and milk product consumption.

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[2] See Tables D1-13 and D1-16 for information on children age 2 to 3 years.

Additional Important Information

- When increasing intake of fruits, vegetables, whole grains, and nonfat or low-fat milk and milk products, it is important to decrease one's intake of other less-nutrient-dense foods to control calorie intake.
- As illustrated by the comparison of whole wheat and enriched white flours in Table E-12, whole grains are richer in many nutrients, but they are not richer in folate unless they have been fortified with folic acid, which currently is allowed for only a few types of whole grain products. Enriched refined grains are required to be fortified with folic acid. Label reading is important.
- Young children and others with low energy needs are encouraged to include three servings of whole grains daily, one of which is a folic acid-fortified breakfast cereal.
- One cannot identify whole grains by the color of the food; label-reading skills are needed. Table E-10 identifies names of whole grains that are widely available in the United States. Table E-13 provides tips to consumers for obtaining information about whole grains from food labels.
- The strength of the evidence for the association between increased intake of fruits and vegetables and reduced risk of chronic diseases is variable and depends on the specific disease, but a wide array of evidence points to beneficial health effects.
- Adults and children should not avoid nonfat or low-fat milk and milk products because of concerns that these foods are "fattening." Even the lowest calorie (1,000 calorie) USDA food pattern includes them.
- When considering milk alternatives, the most reliable and easiest way to derive the health benefits associated with dairy consumption is to choose alternatives within the dairy food group, such as yogurt or lactose-free milk.
- Fruits, vegetables, whole grains, and milk products contain sugars and/or starches. These sugars and starches (like those provided by added sugars and refined cereals) provide fermentable substrates for bacteria that, in turn, can cause dental caries. However, good oral hygiene and fluoridation protect against caries.

Choose Fats Wisely for Good Health

Overview

Fats and oils are part of a healthful diet, but the type of fat makes a difference to heart health, and the amount of fat consumed also is important. High intakes of saturated fats, *trans* fats, and cholesterol increase the risk of unhealthy blood lipid levels, which, in turn, may increase the risk of coronary heart disease. A high intake of fat (greater than 35 percent of energy) generally increases saturated fat intake and makes it more difficult to avoid consuming excess calories. A low intake of fats and oils (less than 20 percent of energy) increases the risk of inadequate intakes of vitamin E and of essential fatty acids and may contribute to unfavorable changes in high-density lipoprotein (HDL) cholesterol and triglycerides. Fish contains oils that may have beneficial effects on mortality from coronary heart disease.

Key Messages

- To decrease their risk of an elevated low-density lipoprotein (LDL) cholesterol, most Americans need to decrease their intakes of saturated fat and *trans* fat, and many (especially men because of their high cholesterol intake) need to decrease their dietary intake of cholesterol.
- Recommended goals are less than 10 percent of calories from saturated fat and less than 300 mg of cholesterol per day for adults with an LDL cholesterol less than 130 mg/dL. Even lower intakes (less than 7 percent of calories from saturated fat and less than 200 mg of cholesterol) are recommended for adults with an elevated LDL cholesterol (greater than 130 mg/dL). Persons with an elevated LDL cholesterol value should be under the care of a healthcare provider.
- *Trans* fatty acid consumption should be kept as low as possible—about 1 percent of energy intake or less.
- Decreasing one's intake of saturated fat and *trans* fat is the recommended way to reduce fat intake so that total fat intake does not exceed 35 percent of calories.
- Consuming two servings of fish per week (approximately 8 ounces total) may reduce the risks from cardiovascular disease, especially mortality from coronary heart disease. The intake of salmon, trout, light tuna, mackerel, or other fish that are high in eicosapentaenoic acid (EPA) and docosahexanoic acid (DHA) may be

especially beneficial. Other sources of EPA and DHA may provide similar benefits; however, more research is needed.

Additional Important Information

- Recommended total fat intake is between 20 and 35 percent of energy for adults. Few Americans consume less than 20 percent of calories from fat.
- General information about fatty acids appears at the beginning of Part D, Section 4, "Fats."
- Because dietary intake of saturated fat is much higher than that of *trans* fat and cholesterol, it is most important to decrease one's intake of saturated fat. However, intake of all three should be decreased. Table E-14 shows, for selected calorie levels, the maximum amounts of saturated fat to consume to keep saturated fat intake below 10 percent of total calorie intake. This table may be useful when combined with label reading guidance. Table E-2 gives a few practical examples of the differences in the saturated fat content of different forms of commonly consumed foods.
- Table E-15 provides the dietary sources of saturated fats in the U.S. diet listed in decreasing order. Table E-16 provides strategies for decreasing saturated fat intake.
- Because *trans* fatty acids are produced in the hydrogenation of vegetable oils and account for more than 80 percent of total intake, the food industry has a large role to play in helping consumers decrease their *trans* fat intake. Table E-17 provides dietary sources of *trans* fat listed in decreasing order.
- Table E-18 provides dietary sources of cholesterol.
- Consumer advisories provide current information about lowering exposure to environmental contaminants, such as methylmercury, in fish. For more information on the latest methylmercury advisory, see *www.fda.gov/bbs/topics/news/2004/NEW01038.html.*

Choose Carbohydrates Wisely for Good Health

Overview

Carbohydrates are part of a healthful diet. Sugars and starches supply energy to the body in the form of glucose, which is the only energy source for red blood cells and is the preferred energy source for the brain, central nervous system, placenta, and fetus. Dietary fiber has been shown to have a number of beneficial effects including decreased risk of type 2 diabetes and of coronary heart disease, and improvement in laxation. Although the body's response to sugars does not depend on whether they are naturally present in a food (such as the fructose in fruit or the lactose in milk) or added to the food, there is a concern that people should not consume excessive amounts of foods that supply calories but few or no nutrients. This is the case for many foods that contain added sugars.

Key Messages

- As described earlier under "Increase Daily Intake of Fruits and Vegetables, Whole Grains, and Nonfat or Low-Fat Milk and Milk Products," consuming foods from the basic food groups that provide carbohydrates can promote health and reduce chronic disease risk. Foods in these groups are important sources of many nutrients.
- When selecting foods from the fruit, vegetable, and grains groups, it is beneficial to make fiber-rich choices often. This means, for example, choosing whole fruits rather than juices and whole grains rather than refined grains. Table D-18 lists some of the best sources of dietary fiber.
- Reducing intake of added sugars (especially sugar-sweetened beverages) can reduce calorie intake, and may be helpful in achieving recommended nutrient intakes and weight control. A reduced intake of added sugars (especially sugar-sweetened beverages) can lower calorie intake, and may be helpful in achieving recommended intakes of nutrients and in weight control.
- A combined approach of reducing the frequency of consuming sugars and starches (e.g., limiting snacking on foods that contain these carbohydrates) and optimizing oral hygiene practices is advised to reduce caries incidence.

Additional Important Information

- The concern about added sugars is not the sugar itself but rather with many of the foods in which added sugars are found. Individuals who consume food or beverages high in added sugars tend to consume more calories than those who consume low amounts of added sugars; they also tend to consume lower amounts of micronutrients.

- The major sources of added sugars are listed in Table E-19. Decreased intake of such foods is recommended.
- Moderate amounts of sugars added to nutrient-dense foods such as breakfast cereals and reduced-fat milk products may increase a person's intake of such foods and thus improve nutrient intake without contributing excessive calories.
- Table E-20 lists ingredients that are included in the term ***added sugars***. Nutritional labels list the amount of total sugars but not added sugars. To find out whether a food contains added sugars, one must examine the ingredient list (Table E-21).

Choose and Prepare Foods with Little Salt

Overview

On average, the higher one's salt intake, the higher one's blood pressure. Keeping blood pressure in the normal range reduces one's risk of coronary heart disease, stroke, congestive heart failure, and kidney disease. Nearly all American adults will develop hypertension (high blood pressure) during their lifetime. Lifestyle changes can prevent or delay the onset of high blood pressure and can lower elevated blood pressure. These lifestyle changes include reducing salt intake, increasing potassium intake, losing excess body weight, increasing physical activity, and eating an overall healthful diet (such as diets based on the revised USDA food intake pattern or the DASH diet described in this report).

Key Messages

- Nearly all Americans consume substantially more salt than they need. Decreasing salt (sodium chloride) intake is advisable to reduce the risk of elevated blood pressure. Expressed in terms of sodium, the general goal is for adults to aim to consume less than 2,300 mg of sodium per day.
- Many persons, such as hypertensive individuals, blacks, and middle-aged and older adults, will benefit from reducing their salt intake even more.
- At the same time, individuals are encouraged to increase their consumption of foods rich in potassium. Potassium lowers blood pressure and blunts the effects of salt on blood pressure.
- Since sodium added during the processing of foods provides more than three-fourths of total intake, the food industry has a large role to play in helping consumers decrease their sodium intake.

Additional Important Information

- Salt is sodium chloride.
- Food labels list sodium rather than salt content. Sources of sodium in the food supply are provided in Figure E-2.
- Many processed foods and foods served by food establishments are high in sodium. See Table E-22 for examples of these foods and Table E-23 for examples of strategies to decrease sodium intake.
- One's preference for salt is not fixed. After consuming foods low in salt for a period of time, one's taste for salt tends to decrease. Alternative flavorings may help. Table E-24 provides examples of alternative flavorings and foods to pair with seasonings.

If You Drink Alcoholic Beverages, Do So In Moderation

Overview

The consumption of alcohol can have beneficial or harmful effects depending on the amount consumed, the age and other characteristics of the person consuming the alcohol, and specific situations. The lowest all-cause mortality occurs at an intake of one to two drinks per day. The lowest coronary heart disease mortality also occurs at an intake of one to two drinks per day. Morbidity and mortality are highest among those drinking large amounts of alcohol.

Key Messages

- Those who choose to drink alcoholic beverages should do so sensibly and in moderation.
- Abstention is an important option; approximately one in three American adults do not drink alcohol.
- Moderation is defined as the consumption of up to one drink per day for women and up to two drinks per day for men. One drink is defined as 12 ounces of regular beer, 5 ounces of wine (12 percent alcohol), or 1.5 ounces of 80-proof distilled spirits.
- Drinking alcoholic beverages should be avoided before or when driving, or whenever it puts anyone at risk.

Additional Important Information

- The definition of moderation, including the size of one drink, requires emphasis. Some investigators and apparently many individuals interpret "moderate drinking" to cover higher levels of intake than shown in Table E-25. Many mixed drinks actually provide several servings of alcohol per drink. (See Table E-3.)
- Studies suggest adverse effects even at moderate alcohol consumption levels in specific individuals and situations.
  - Some people should not drink alcohol (e.g., individuals who cannot restrict alcohol intake, children and adolescents, individuals taking medications that can interact with alcohol, and individuals with specific medical conditions).
  - In some situations, alcohol should be avoided (e.g., women who may become or are pregnant; women who are breastfeeding; and individuals who plan to drive, operate machinery, or take part in other activities that require attention, skill, or coordination).
- Factors other than moderate alcohol consumption that may reduce the risk of chronic disease include a healthful diet (see above), physical activity, avoidance of smoking, and maintenance of a healthy weight.
- Compared with nondrinkers, women who consume one drink per day appear to have a slightly higher risk of breast cancer.
- The consumption of one to two alcoholic beverages per day is not associated with macronutrient or micronutrient deficiencies or with overall dietary quality. Nonetheless, the calorie content of alcoholic beverages should be considered. (See Table E-3.)

Keep Food Safe To Eat

Overview

Foodborne illness results from eating food contaminated with bacteria (or their toxins) or other pathogens such as parasites or viruses. The signs and symptoms range from upset stomach to diarrhea, fever, vomiting, abdominal cramps, and dehydration. It is estimated that every year about 76 million people in the United States become ill from pathogens in food; of these, about 5,000 die. The foodborne illness listeriosis, although rare, has very serious public health consequences—it can be life threatening for vulnerable groups. Consumers can take simple measures to reduce their risk of foodborne illness, especially in the home.

Key Messages

- The most important food safety problem is microbial foodborne illness. The behaviors in the home that are most likely to prevent a problem with foodborne illnesses are
  - Cleaning hands, contact surfaces, and fruits and vegetables. (This does not apply to meat and poultry, which should not be washed.)
  - Separating raw food from cooked and ready-to-eat foods while shopping, preparing, or storing
  - Cooking foods to a safe temperature
  - Chilling (refrigerating) perishable foods promptly
- Avoiding higher risk unsafe foods also is an important protective measure, especially for high-risk groups (the very young, pregnant women, elderly, and those who are immunocompromised).

Additional Important Information

- For more information on cleaning, separating, cooking, chilling, and consumer messages, see *www.fightbac.org*.
- Table D9-1 provides a protocol for washing hands.
- Table D9-2 provides a protocol for washing fruits and vegetables.
- Figure E-3 provides information for temperature rules for proper cooking.
- Refrigerated leftovers may become unsafe within 3 to 4 days. Despite the appearance of a food, it may not be safe to eat. Not all bacterial growth causes a food's surface to discolor or smell bad. It may be unsafe to taste fresh or leftover food items when there is any doubt about their safety. Safe disposal of the food is indicated if there is a question about whether or not a food is safe to eat.
- Those at risk of listeriosis (pregnant women, older adults, and those who are immunocompromised) should avoid high-risk foods, including deli meats and frankfurters that are not reheated to

a safe temperature. See Table E-26 for tips for those at increased risk of foodborne illness.

- Guidance is evolving on reducing dietary exposure to environmental contaminants, including methylmercury in fish. Thus, referring to consumer advisories is recommended to obtain updates on this topic. (For more information on the latest methylmercury advisory, see *www.fda.gov/bbs/topics/news/2004/NEW01038.html*.)
- Refrigerator surfaces can become contaminated from contact with high-risk foods such as raw meats, poultry, fish, uncooked hotdogs, certain deli meats, or raw vegetables. If not cleaned, affected refrigerator surfaces can, in turn, serve as a vehicle for contaminating other foods.
- Chilling should take place at any stage of food handling during which raw foods are not being cleaned or cooked. For example, when shopping, it is advisable to buy perishable foods last, take them straight home, and chill them. Until cooking takes place (e.g., while other foods are being prepared), chilling is indicated after handling or preparing perishable foods (especially raw meat, poultry, fish, shellfish, or eggs).

Table E-1. Essential elements of weight loss

- The energy you get from consuming food should be less than the energy you expend.
- Caloric intake must be decreased to attain weight loss.
- Caloric reduction, regardless of macronutrient distribution, can result in weight loss.
- A diet based on the basic food groups may be safer and easier to follow on a long-term basis, while providing adequate amounts of essential nutrients and limiting saturated and *trans* fats and cholesterol.
- Increased physical activity will use up more energy, which can help in weight reduction.

Adapted from ASCM Position Stand "Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain in Adults."

Table E-2. Differences in saturated fat and calorie content of commonly consumed foods

A Comparison of Saturated Fat in Some Foods

Food category	**Portion**	**Saturated fat content in grams**	**Calories**
Cheese			
Regular cheddar cheese	1 oz.	6.0	114
Low-fat cheddar cheese	1 oz.	1.2	49
Ground beef			
Regular ground beef (25% fat)	3 oz. (cooked)	6.1	236
Extra lean ground beef (5% fat)	3 oz. (cooked)	2.6	148
Milk			
Whole milk (3.24%)	1 cup	4.6	146
Low-fat (1%) milk	1 cup	1.5	102
Breads			
Croissant (med)	1 medium	6.6	231
Bagel, oat bran (4")	1 medium	0.2	227
Frozen desserts			
Regular ice cream	½ cup	4.9	145
Frozen yogurt	½ cup	2.0	110
Table spreads			
Butter	1 tsp.	2.4	34
Trans-free soft margarine	1 tsp.	0.7	25
Chicken			
Fried chicken (leg)	3 oz. (cooked)	3.3	212
Chicken breast	3 oz. (cooked)	0.9	140
Fish			
Fried fish	3 oz.	2.8	195
Baked fish	3 oz.	1.5	129

Source: ARS Nutrient Database for Standard Reference, Release 17.

Table E-3. Estimated caloric content of alcoholic beverages*

Information on some typical drinks requested and consumed by Americans was collected from several online sources. An Internet search identified a Web site with consistent dietary information and recipes (*www.drinksmixer.com*). Other potential resources (e.g., trade associations, consumer groups, company web sites) yielded little or no information on the caloric content of mixed drinks (made with liquor).

Alcoholic beverage	**Beverage serving size**	**Number of alcohol servings/ beverage**	**Calories**
Beer[+]	12 oz.	1	150
Light beer[+]	12 oz.	1	110
Dark beer[+]	12 oz.	1	168
Non-alcoholic beer[+]	12 oz.	1	70
Distilled spirit	1.5 oz.	1	100
Dry dessert wine[+++]	5 oz.	1	198
Sweet dessert wine[+++]	5 oz.	1	344
Red wine[+++]	5 oz.	1	105
White wine[+++]	5 oz.	1	100
Sparkling white wine[+++]	5 oz.	1	106
Amaretto sour[++] (Sweet and sour mix, almond amaretto liqueur, tequila, orange juice)	6 oz.	4	421
B-52[++] (Kahlua coffee liqueur, amaretto almond liqueur, Bailey's Irish Cream)	1.5 oz.	1	91
Bloody Mary[++] (vodka, tomato juice, lemon juice, Worcestershire sauce, Tabasco sauce, lime)	4.6 oz.	1	120
Chocolate martini[++] (Vodka, crème de cacao)	2.5 oz.	1.67	188
Cosmopolitan[++] (vodka, triple sec, Rose's lime juice, cranberry juice)	2.5 oz.	1.67	131
Daiquiri[++] (light rum, limes, powdered sugar)	2.7 oz.	1	137
Gin and tonic[++] (gin, tonic water, lime)	7 oz.	1.33	189
Hurricane[++] (dark rum, light rum, orange juice, pineapple juice, grenadine,	10.4 oz.	3	384

Alcoholic beverage	Beverage serving size	Number of alcohol servings/ beverage	Calories
151 proof rum, cherries, pineapple, sugar)			
Irish Coffee++ (Irish whiskey, coffee, sugar, whipped cream)	10.2 oz.	1	159
Kamikaze++ (vodka, triple sec, lime juice)	3 oz.	1	180
Mai Tai++ (dark rum, light rum, sweet and sour mix, grenadine, 151 proof rum, ice)	4.9 oz.	1.82	306
Manhattan++ (whisky, vermouth, bitters)	2.1 oz.	1.33	132
Margarita++ (coarse salt, lime, white tequila, triple sec, lime juice, crushed ice)	6.3 oz.	3	327
Martini++ (gin, dry vermouth)	2 oz.	1.33	119
Mudslide++ (vodka, coffee liqueur, Irish cream, vanilla ice cream)	12 oz.	4	820
Pina colada++ (Malibu rum, pineapple juice, cream)	8 oz.	2.13	312
Rum and Coke++++ (rum, cola)	12 oz.	2.67	361
Screwdriver++ (vodka, orange juice)	7 oz.	1.33	208
Whiskey sour++ (whiskey, lemon juice, powdered sugar, cherry, lemon slice)	3 oz.	1.33	125

*Caloric content will vary by recipe.

+ Anheuser-Busch Web site. Available at *www.anheuser-busch.com*. Accessed on June 2, 2004.

++ Drinkmixer Web site. Available at *www.drinksmixer.com*. Accessed on June 2, 2004.

+++ Calorie King. Available at *www.calorieking.com*. Accessed on June 2, 2004.

++++ Recipe provided by *www.webtender.com* as "typical rum and Coke recipe." Serving size is based on the recipe, and calorie information was calculated with Coca-Cola calorie information and rum.

Table E-4. How portion sizes have changed

Food item	Calories per portion 20 years ago	Calories per portion today
Bagel	140 calories (3 in. diameter)	350 calories (6 in. diameter)
Fast food cheeseburger	333 calories	590 calories
Spaghetti and meatballs	500 calories (1 cup of spaghetti with sauce and 3 small meatballs)	1,025 calories (2 cups of spaghetti and 3 large meatballs)
Bottle of soda	85 calories (6.5 oz.)	250 calories (20 oz.)
Fast food French fries	210 calories (2.4 oz)	610 calories (6.9 oz)
Turkey sandwich	320 calories	820 calories (10 in. sub)

Adapted from the Portion Distortion Quiz on the NHLBI Web site.

Table E-5. Strategies to reduce calories in your diet

- Instead of sugar-sweetened soft drinks, try a diet soda or water or at least reduce the amount of regular soft drinks you consume by 8 ounces (1 cup).
- Have a toasted English muffin with 2 teaspoons of no-sugar-added preserves instead of a croissant or sweet roll.
- Pick water-packed tuna instead of tuna packed in oil.
- Skip the cream-based or cheese sauce on your vegetables.
- Go for just a half cup of regular (10% fat) ice cream instead of rich (16% fat) or premium (18%–20% fat) ice cream.
- Follow the low-fat directions when preparing brownie, cake, and cookie mixes.
- Enjoy canned fruit packed in water or its natural juice instead of heavy syrup.
- Lighten up your favorite coffee drink by requesting nonfat milk and using half the sugar or flavored syrup.

For more examples, visit *www.americaonthemove.org*.

Used with permission from America On the Move (*www.americaonthemove.org*).

Table E-6. Kcals/hour expended in common physical activities

Moderate Physical Activity	**Kcals/hr for a 154-lb person[1]**
Hiking	367
Light gardening/yard work	331
Dancing	331
Golf (walking and carrying clubs)	331
Bicycling (<10 mph)	294
Walking (3.5 mph)	279
Weight lifting (general light workout)	220
Stretching	184
Vigorous Physical Activity	**Kcals/hr for a 154-lb person[1]**
Running/jogging (5 mph)	588
Bicycling (>10 mph)	588
Swimming (slow freestyle laps)	514
Aerobics	478
Walking (4.5 mph)	464
Heavy yard work (chopping wood)	441
Weight lifting (vigorous effort)	441
Basketball (vigorous)	441

[1]For a 154-lb individual, calories burned per hour will be higher for persons who weigh more than 154 lbs and lower for persons who weigh less.
NHANES 1999–2000

Table E-7. Daily Amount of Fruits and Vegetables by Calorie Level

	Daily/weekly amount of fruits and vegetables for consumption											
Calorie level	**1000**	**1200**	**1400**	**1600**	**1800**	**2000**	**2200**	**2400**	**2600**	**2800**	**3000**	**3200**
Fruits cups/day	1	1	1.5	1.5	1.5	2	2	2	2	2.5	2.5	2.5
Vegetables cups/day	1	1.5	1.5	2	2.5	2.5	3	3	3.5	3.5	4	4
Dark green cups/wk	1	1.5	1.5	2	3	3	3	3	3	3	3	3
Orange cups/wk	0.5	1	1	1.5	2	2	2	2	2.5	2.5	2.5	2.5
Starchy cups/wk	1.5	2.5	2.5	2.5	3	3	6	6	7	7	9	9
Other cups/wk	4	4.5	4.5	5.5	6.5	6.5	7	7	8.5	8.5	10	10
Legumes cups/wk	1.5	1	1	2.5	3	3	3	3	3.5	3.5	3.5	3.5

Table E-8. Which fruits and vegetables provide the most nutrients?

The lists below show which fruits and vegetables are the best sources of vitamin A (carotenoids), vitamin C, folate, and potassium. Often, the brighter the color, the higher the content of vitamins and minerals. Eat at least two servings of fruits and at least three servings of vegetables each day.

Sources of vitamin A (carotenoids)

- Bright orange vegetables like carrots, sweetpotatoes, and pumpkin
- Dark green leafy vegetables such as spinach, collards, and turnip greens
- Bright orange fruits like mango, cantaloupe, and apricots

Sources of vitamin C

- Citrus fruits and juices, kiwi fruit, strawberries, and cantaloupe
- Broccoli, peppers, tomatoes, cabbage, and potatoes
- Leafy greens such as romaine, turnip greens, and spinach

Sources of folate

- Cooked dried beans and peas
- Oranges and orange juice
- Deep green leaves like spinach and mustard greens

Sources of potassium

- Baked white potatoes or sweetpotatoes, cooked greens (such as spinach), winter (orange) squash
- Bananas, plantains, many dried fruits, and orange juice

Table E-9. Ways to increase consumption of fruits and vegetables

- Include one or more fruit or vegetable choice(s) at all meals and snacks.
- Toss fruit into your green salad for extra flavor, variety, color, and crunch.
- Frozen fruits and vegetables and canned fruit (in 100% fruit juice) or vegetables are perfect for busy lifestyles.
- Save time with pre-cut vegetables and salad mixes.
- Add apples, raisins, or pineapple chunks to deli salads like chicken, tuna, or pasta.
- Add frozen mixed vegetables to canned or dried soups.
- Make a quick smoothie using frozen fruit.
- Keep an easy-to-grab pre-washed bowl of fruit on the counter.
- At work keep dried fruit and nuts in your desk drawer for quick and easy snacks.
- Try fajitas with red bell peppers, summer squash, and garlic.

Adapted from Produce for Better Health:
www.5aday.com/html/consumers/easyway.php, and *www.5aday.com/html/consumers/faqs.php - getmore.*

Table E-10. Whole grains that are widely available in the United States

- Brown rice
- Bulgur (cracked wheat)
- Graham flour (coarsely ground whole wheat flour)
- Oatmeal
- Pearl barley
- Popcorn
- Whole grain corn
- Whole oats
- Whole rye
- Whole wheat

Note: Wheat flour, enriched flour, and degerminated corn meal are not whole grains.

Table E-11. Ways to increase consumption of milk and milk products

- Include milk or milk products at all meals and snacks.
- Add low-fat milk instead of water to oatmeal and hot cereals.
- Eat cereals with calcium added and with milk.
- Top bread with low-fat cheese and pop it under the broiler for a quick toasted cheese sandwich.
- Add low-fat or nonfat milk instead of water to creamed soups, such as tomato.
- Include milk and/or milk products in lunches for children.
- Serve hot chocolate made from low-fat milk and chocolate syrup.
- Cut up raw vegetables for dipping into a low-fat yogurt dip.
- Whip up fruit and yogurt smoothies in the blender.
- Try some pudding made with milk.
- Top salads, soups, and stews of fresh vegetables with low-fat shredded cheese.
- Use flavored yogurts as topping for fruit for dessert.
- Top a baked potato with low-fat yogurt or low-fat or nonfat sour cream.

Adapted from NIH: *www.nichd.nih.gov/milk/whycal/helpful_tips.cfm*

Table E-12. Comparison of 100 grams of whole-grain wheat flour and enriched, bleached, white, all-purpose flour

	100 percent whole wheat flour	**Enriched white flour**
Calories, kcal	339.0	364.0
Dietary fiber, g	12.2	2.7
Calcium, mg	34.0	15.0
Magnesium, mg	138.0	22.0
Potassium, mg	405.0	107.0
Folate, DFE, mcg	44.0	291.0

Source: USDA Food Composition Database, SR-16.

Table E-13. Tips for finding whole-grain information on food labels

- Read the ingredient list on the food label. For many whole-grain products, the words ***whole*** or ***whole grain*** will appear before the grain ingredient's name. The whole grain should be the first ingredient listed.
- Wheat flour, enriched flour, and degerminated cornmeal are *not* whole grains. A list of some common whole grains found in the U.S. food supply are listed in Table E-10
- Look for the whole-grain health claim—"Diets rich in whole-grain foods and other plant foods and low in total fat, saturated fat, and cholesterol may help reduce the risk of heart disease and certain cancers"—on food product labels. Foods that bear the whole-grain health claim must—
  - — Contain 51 percent or more whole grains by weight
  - — Be low in fat

Table E-14. Maximum daily amounts of saturated fat to consume to keep saturated fat below 10 percent of total calorie intake

Total calorie intake	Limit on saturated fat intake
1,600	18 g or less
2,000*	20 g or less
2,200	24 g or less
2,500*	25 g or less
2,800	31 g or less

*Percent Daily Values on Nutrition Facts Labels are based on a 2,000-calorie diet. Values for 2,000 and 2,500 calories are rounded to the nearest 5 grams to be consistent with the Nutrition Facts Label.

Table E-15. Dietary sources of saturated fat listed in decreasing order

Food group	Saturated fat 1994–1996 (mean = 25.5 g)		
	Ranking	**Percent total**	**Percent cumulative**
Cheese	1	13.1	13.1
Beef	2	11.7	24.8
Milk	3	7.8	32.6
Oils	4	4.9	37.5
Ice cream/sherbet/frozen yogurt	5	4.7	42.2
Cakes/cookies/quick breads/doughnuts	6	4.7	46.9
Butter	7	4.6	51.5
Other fats*	8	4.4	55.9
Salad dressings/mayonnaise	9	3.7	59.6
Poultry	10	3.6	63.2
Margarine	11	3.2	66.4
Sausage	12	3.1	69.5
Potato chips/corn chips/popcorn	13	2.9	72.4
Yeast bread	14	2.6	75.0
Eggs	15	2.3	77.3

*Shortening and animal fats

Adapted from Cotton PA, Subar AF, Friday JE, Cook A. Dietary Sources of Nutrients among U.S. Adults, 1994–1996. *JADA* 104:921-931, 2004.

Table E-16. Strategies for decreasing saturated fat intake

Fats and oils

- Choose vegetable oils or *trans*-free soft margarine rather than solid fats (shortening, butter, and hard margarine).

Meat, poultry, fish, shellfish, eggs, beans, and nuts

- Choose very lean meats and trim the fat before eating.
- Remove the skin before eating chicken.
- Select lean ground beef.
- Limit intake of high-fat processed meats such as bacon, sausages, salami, bologna, and cold cuts.
- Use eggs yolks and whole eggs in moderation; use eggs whites and egg substitutes instead.

Dairy products

- Choose fat-free or low-fat milk, yogurt, and cheese.

Table E-17. Dietary sources of *trans* fat listed in decreasing order

Food group	*Trans* fat 1994–1996 (mean = 5.84 g)		
	Ranking	**Percent total**	**Percent cumulative**
Cakes, cookies, crackers, pies, bread, etc	1	40	40
Animal products	2	21	61
Margarine	3	17	78
Fried potatoes	4	8	86
Potato chips, corn chips, popcorn	5	5	91
Household shortening	6	4	95
Other*	7	5	

* Includes breakfast cereal and candy. USDA analysis reported 0 grams of *trans* fat in salad dressing.

Adapted from *Federal Register* notice. *Food Labeling; Trans Fatty Acids in Nutrition Labeling; Consumer Research To Consider Nutrient Content and Health Claims and Possible Footnote or Disclosure Statements; Final Rule and Proposed Rule.* Vol. 68, No. 133, p. 41433-41506, July 11, 2003.

Table E-18. Dietary sources of cholesterol listed in decreasing order

Food group	Cholesterol 1994–1996 (mean = 270mg)		
	Ranking	**Percent total**	**Percent cumulative**
Eggs	1	29.3	29.3
Beef	2	16.1	45.4
Poultry	3	12.2	57.6
Cheese	4	5.8	63.4
Milk	5	5.0	68.4
Fish/shellfish*	6	3.7	72.1
Cakes/cookies/quick breads/doughnuts	7	3.3	75.4
Pork (fresh unprocessed)	8	2.8	78.2
Ice cream/sherbet/frozen yogurt	9	2.5	80.7
Sausage	10	2.0	82.7

*This category does not include canned tuna.

Adapted from Cotton PA, Subar AF, Friday JE, Cook A. Dietary Sources of Nutrients among U.S. Adults, 1994–1996. *JADA* 104:921-931, 2004.

Table E-19. Major sources of added sweeteners in the American diet

Each of the food categories listed below provide more than 5 percent of the added sweeteners consumed in the United States.

Food categories	**Percent contribution to added sweeteners**
Soft drinks	33.0
Sugars and candy	16.1
Sweetened grains, such as cakes, cookies, and pies	12.9
Fruit drinks, such as fruitades and fruit punch	9.7
Dairy desserts and milk products, such as ice cream, sweetened yogurt, and sweetened milk	8.6
Other grains, such as cinnamon toast and honey-nut waffles	5.8

Source: Guthrie and Morton, *Journal of the American Dietetic Association*, 2000.

Table E-20. Sugars that appear on food labels

- Brown sugar
- Corn sweetener
- Corn syrup
- Dextrose
- Fructose
- Fruit juice concentrate
- Glucose
- High-fructose corn syrup
- Honey
- Invert sugar
- Lactose
- Maltose
- Malt syrup
- Molasses
- Raw sugar
- Sucrose
- Syrup
- Table sugar

Table E-21. Finding added sugars on food label ingredient lists

The ingredient list is usually located under the Nutrition Facts panel or on the side of a food label. Ingredients are listed in order by weight. The ingredient in the greatest amount by weight is listed first and the one in the least amount is listed last. For example, in the ingredient list below, corn syrup is the second ingredient listed and sugar is the third, which means that combined these two sugars are main ingredients in the apple pie.

Baked Apple Pie
Ingredient list: Apples, corn syrup, sugar, water, modified corn starch, dextrose, brown sugar, sodium alginate, spices, citric acid, salt, dicalcium phosphate. In a pastry consisting of enriched bleached wheat flour (niacin, reduced iron, thiamine mononitrate, riboflavin, folic acid), vegetable shortening (partially hydrogenated soybean and/or cottonseed oil), water, sugar, less than 2 percent of salt, yeast, l-cysteine (dough conditioner), lecithin.

Table E-22. Range of sodium content for selected foods (in milligrams)

Food group	**Serving size**	**Range**
Breads	1 oz.	95–210
Frozen pizza	4 oz.	710–1200
Frozen vegetables	1 c	95–300
Salad dressing	2 Tbsp.	110–400
Salsa	2 Tbsp.	150–240
Soup (tomato)	8 oz.	700–1100
Tomato juice	8 oz.	480–800

Sources: Manufacturers. Foods were randomly selected on the grocery store shelf. Serving sizes were comparable.
Note: None of the examples provided were low-sodium products.

Table E-23. Strategies for reducing sodium intake

- At the store
  - Choose fresh, plain frozen, or canned vegetables without added salt most often; they are low in salt.
  - Choose fresh or frozen fish, shellfish, poultry, and meat most often. They are lower in salt than most canned and processed forms.
  - Read the Nutrition Facts Label to compare the amount of sodium in processed foods, such as frozen dinners, packaged mixes, cereals, cheese, breads, soups, salad dressings, and sauces. The amount in different types and brands often varies widely.
  - Look for labels that say ***low sodium***. They contain 140 mg (about 5% of the Daily Value) or less of sodium per serving.
  - Ask your grocer or supermarket to offer more low-sodium foods.
- Cooking and eating at home
  - If you salt foods in cooking or at the table, add small amounts. Learn to use spices and herbs, rather than salt, to enhance the flavor of food.
  - Go easy on condiments such as soy sauce, ketchup, mustard, pickles, and olives; they can add a lot of salt to your food.
  - Leave the saltshaker in the cupboard.
- Eating out
  - Choose plain foods like grilled or roasted entrees, baked potatoes, and salad with oil and vinegar. Batter-fried foods tend to be high in salt, as do combination dishes like stews or pasta with sauce.
  - Ask to have no salt added when the food is prepared.
- Any time
  - Choose fruits and vegetables often.
  - Drink water freely. It is usually very low in sodium. Check the label on bottled water for sodium content.

Table E-24. Alternative flavorings for salt and uses for these flavorings

Food	Alternative flavoring
Lean meats	Bay leaves, caraway seeds, chives, mustard, lemon juice, garlic, curry powder, onion, paprika, parsley, sage, thyme, allspice, turmeric
Veal	Thyme, mace, curry powder, nutmeg
Lamb	Basil, curry powder, dill, mace
Lean pork	Thyme, savory, rosemary, sage
Poultry (chicken)	Rosemary, nutmeg, mustard, lemon juice, ginger, dill, curry powder, bay leaves
Lean ground meats	Allspice, basil, mustard, savory
Lean meat loaf	Rosemary, nutmeg
Stews	Allspice, bay leaves, onion, sage, caraway seeds, basil
Soups	Thyme, savory, parsley, paprika, onion, basil, chives, curry powder, dill, garlic, bay leaves
Breads	Caraway seeds, nutmeg (toast), sage (biscuits), rosemary (stuffing), cinnamon, mace
Salads	Basil, dry mustard, savory, caraway seeds, chives, cider vinegar, garlic, lemon juice, dill, paprika, parsley, pimiento, onion, thyme
Fruit	Almond extract, ginger, cinnamon (especially apples), nutmeg, peppermint extract, mace, allspice (especially in peaches, applesauce, and cranberry sauce)
Vegetables	Lemon juice, chives, dill, cider vinegar, pimiento, parsley, dry mustard, garlic, mace, onion, paprika
Tomatoes	Allspice, bay leaves, curry powder, garlic, dill, thyme, savory, sage
Potatoes	Nutmeg, mace, garlic, dill, rosemary
Onions	Thyme, sage
Green beans, lima beans, or peas	Savory, sage, rosemary, thyme
Pie crust	Nutmeg, cinnamon
Puddings	Peppermint extract, almond extract, nutmeg
Mayonnaise	Curry powder, dry mustard
Sauces	Basil, turmeric, rosemary, thyme, chives, cider vinegar, paprika, parsley, dry mustard

Table E-25. Moderate drinking definition

What is drinking in moderation?

- Moderation is defined as no more than one drink per day for women and no more than two drinks per day for men.

Count as one drink—

- 12 ounces of regular beer
- 5 ounces of wine (12% alcohol)
- 1.5 ounces of 80-proof distilled spirits

Table E-26. Tips for those at high risk of foodborne illness

Who is at high risk of foodborne illness?
What foods are high risk and support the growth of *Listeria monocytogenes*?

Tips for Those at High Risk of Foodborne Illness

Who is at high risk of foodborne illness?

- Pregnant women and their fetuses
- Young children
- Older persons
- People with weakened immune systems or certain chronic illnesses
- Individuals with pre-existing illness

Which foods are associated with listeriosis and pose a high risk to certain high-risk and sensitive individuals?

- Some deli meats (excluding those that are very salty, such as some ham, or low in water activity, such as salami) and frankfurters that have not been reheated to steaming hot; some ready-to-eat foods.

Besides following the guidance in this guideline, some of the *extra* precautions those at high risk should take are—

- Do not eat or drink unpasteurized juices, raw sprouts, raw (unpasteurized) milk, and products (such as cheese) made from unpasteurized milk.
- Do not eat raw or undercooked meat, poultry, eggs, fish, and shellfish (clams, oysters, scallops, and mussels).

New information on food safety is constantly emerging. Recommendations and precautions for people at high risk are updated as scientists learn more about preventing foodborne illness. If you are among those at high risk, you need to be aware of and follow the most current information on food safety.

For the latest information and precautions, call USDA's Meat and Poultry Hotline, *1-800-535-4555,* or FDA's Food Information Line, *1-888-SAFE FOOD,* or consult your healthcare provider. You can also get up-to-date information by checking the Government's food safety Web site at *www.foodsafety.gov.*

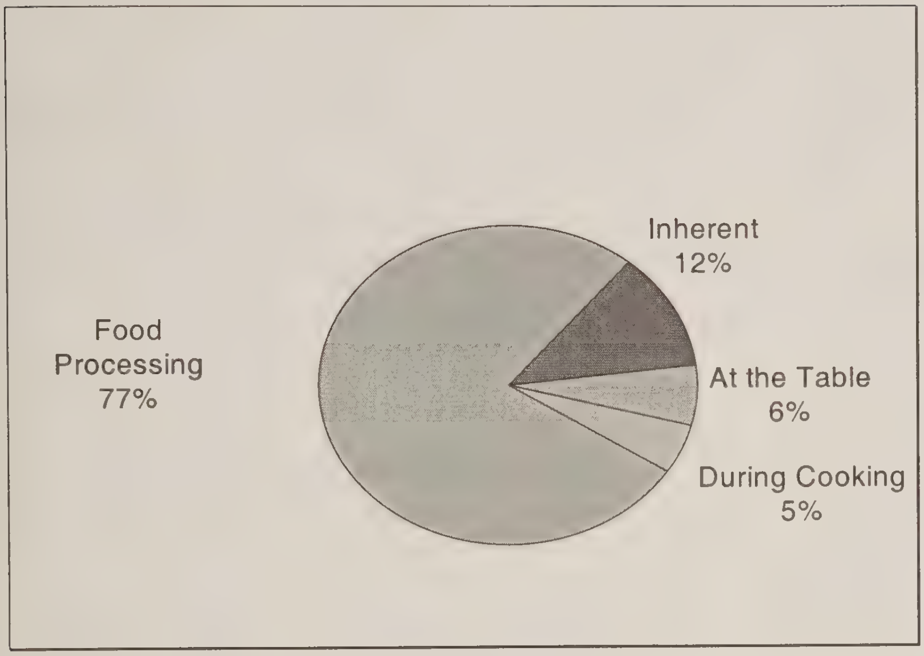
Figure E-1. Adult BMI chart

BMI	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Height	**Weight in Pounds**																
4'10"	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167
4'11"	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173
5'	97	102	107	112	118	123	128	133	138	143	148	153	158	163	158	174	179
5'1"	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185
5'2"	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191
5'3"	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197
5'4"	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204
5'5"	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210
5'6"	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216
5'7"	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223
5'8"	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230
5'9"	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236
5'10"	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243
5'11"	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250
6'	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258
6'1"	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265
6'2"	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272
6'3"	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279

Healthy Weight
Overweight
Obese

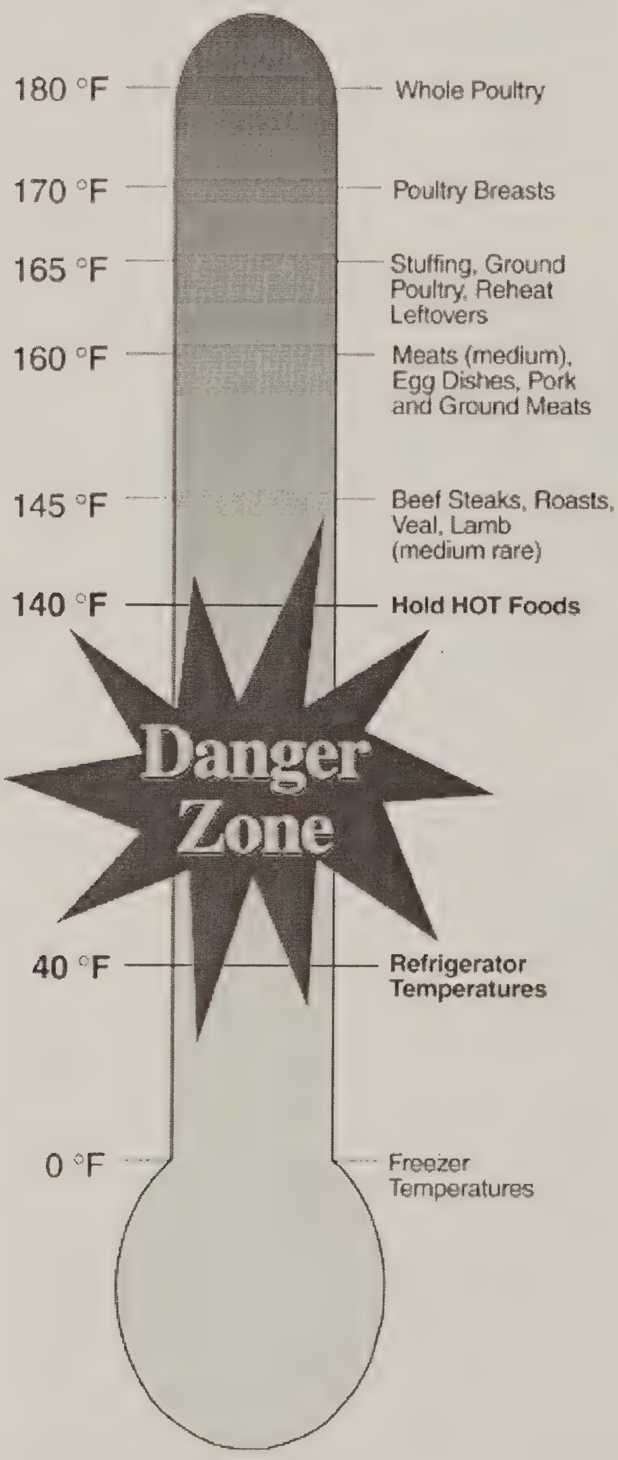
Source: Evidence Report of Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults, 1998. NIH/National Heart, Lung, and Blood Institute (NHLBI).

Figure E-2. Sources of dietary sodium



Source: Mattes and Donnelly, 1991.

Figure E-3. Temperature rules for safe cooking



www.fsis.usda.gov/Frame/FrameRedirect.asp?main=http://www.fsis.usda.gov/OA/pubs/cfg/cfg.htm

Part F: Research Recommendations

General Overarching Research Recommendations

1. Investigate the impact of following adult-based dietary guidelines on nutrient intake and health or metabolic effects in children and later in life. Determine the impact of establishing dietary guidelines in childhood on dietary intakes and patterns later in life.

   Rationale: Research on the effectiveness of using adult-based dietary guidelines for children is limited.

2. Conduct clinical trials to determine the effect of intake of foods from various commodity food groups (i.e., fruits, vegetables, cereals, dairy foods, and meat, fish, or poultry) or whole diets on body mass index (BMI), lipid metabolism, cardiovascular disease, type 2 diabetes, cancer, and osteoporosis.

   Rationale: This report relied heavily on observational studies that assessed the relationship of foods to health outcomes. Available trials typically evaluated the relationship between specific nutrients or food components rather than whole food groups or diets.

3. Establish a system for ongoing systematic reviews on key nutrition and physical activity topics relevant to dietary guidance for the general public.

   Rationale: A system to conduct ongoing evidence-based reviews on topics relevant to dietary guidance for the general public will streamline the tasks for the next Dietary Guidelines Advisory Committee and is in keeping with the Federal Data Quality Act.

4. Develop a scientifically valid definition for "nutrient density" that could be useful on the food label. Determine what criteria are necessary for foods to meet this definition.

   Rationale: Over the past decade, a widespread concern has been that some foods may be classified as less nutrient dense than others and these foods may be eaten at the expense of other foods that are, by comparison, better sources of essential nutrients. To assist consumers in making wise food choices, a method is needed to convey the nutrient density of a food on the label.

5. Conduct studies to determine the barriers for complying with the *Dietary Guidelines* among children, low-income populations, and various ethnic groups. Identify various mechanisms to motivate individuals to change their eating behaviors and habits.

   Rationale: Currently, compliance with the *Dietary Guidelines* is poor. There is a need to understand what barriers prevent compliance and how to motivate individuals to change their eating behaviors and habits and increase compliance with the *Dietary Guidelines*.

6. Develop and test both individual-based and population-based interventions designed to implement *Dietary Guidelines*.

   Rationale: Achieving all *Dietary Guidelines* may be challenging. For instance, it might be difficult to increase the intake of key nutrients without inadvertently increasing calorie consumption. In addition, the extent to which increased physical activity enhances the ability to meet nutrient needs has not been assessed. Strategies that assist the general public and healthcare professionals will be needed, along with evaluation of those strategies.

Specific Research Recommendations

1. Establish the effect of various food components (e.g., flavonoids, other antioxidants, citrate) on metabolism and indicators of health. Develop food composition databases to accurately assess the intake of these food components and conduct human studies to determine the biological function of these dietary constituents.

Rationale: A growing body of scientific evidence suggests that food components may affect the risk of chronic disease, but data are lacking on the intakes of these dietary constituents, their biological function, and their health effects independent of nutrients.

2. Investigate the dietary requirements of vitamin D in vulnerable groups (i.e., older adults, house-bound individuals, and those with dark skin). This research requires the development of a database for the vitamin D content of foods, estimates of usual vitamin D intake from foods, determination of the indicators of vitamin D status and the effect of latitude and seasons on those indicators, and the vitamin D intake required to maintain adequate status in various age and ethnic groups.

   Rationale: Vitamin D is supplied mainly by synthesis in the skin with sunlight exposure, and this synthesis may be adequate in fair-skinned people who are active outdoors, especially in southern states. Older, less active people who stay indoors and those with darkly pigmented skin are more prone to having vitamin D insufficiency. The National Health and Nutrition Examination Survey (NHANES), which monitors vitamin D status only in northern latitudes during the summer months, may not adequately detect insufficiency.

3. Investigate the vitamin E requirements of individuals consuming various types and amounts of dietary fat, the bioavailability of vitamin E from various food sources, and the effect of vitamin E status on the risk of chronic disease. Develop a comprehensive nutrient database for the vitamin E content of foods.

   Rationale: Current data suggest that the vitamin E intakes of Americans are inadequate compared with the Recommended Dietary Allowances. However, the health consequences of chronically low vitamin E intakes are uncertain.

4. Investigate the relationship between added sugar intake and various health outcomes, including BMI (or obesity) and type 2 diabetes.

   Rationale: There is a paucity of longitudinal studies that assessed the long-term effects of added sugars on BMI and other health outcomes. Long-term studies and, if possible, dose-response trials are needed to better understand the relationship between added sugar consumption and health in adults and children.

5. Investigate the relationship between portion size and BMI (or obesity).

   Rationale: There is a lack of longitudinal studies that assessed the long-term effects of differing portion sizes on BMI and obesity. It is important to find out whether a campaign to limit portion size would be effective in the prevention of overweight and obesity.

6. Investigate the relationship between the pattern of food intake (i.e., skipping breakfast or other meals or the frequency of food consumption) and BMI (or obesity).

   Rationale: The effect of skipping meals or frequent snacking on BMI (and obesity) is not clear. Current data are poor and short term. It is important in designing strategies for managing body weight to have a better understanding of the role of pattern of food intake on body adiposity.

7. Investigate the relationship between dietary glycemic load and BMI.

   Rationale: The effect of glycemic response on BMI is uncertain, because evidence from observational studies is inconsistent and because there are few randomized trials. Randomized trials are required to establish whether the dietary glycemic load is an important factor in regulating body fat and altering the risk for type 2 diabetes.

8. Determine how the dietary macronutrient ratio affects management of body weight and nutrient adequacy.

   Rationale: The Institute of Medicine (IOM) recommendations for acceptable macronutrient distribution ranges (AMDR) provide a wide range of carbohydrate, protein, and fat intakes. Various ratios of macronutrients within the

AMDR need to be tested in long-term studies to determine their effects on energy homeostasis and regulation of body weight. Also, nutrient adequacy at the extremes of AMDR (e.g., total protein intake of 35 percent of calories) needs to be assessed.

9. Investigate the effect of various types of fatty acids (i.e., saturated fatty acids, *trans* fatty acids, α-linolenic acid) on the incidence and prevention of cancer.

   Rationale: There is limited evidence on the effect of specific fatty acids on human breast cancer, prostate cancer, and other cancers.

10. Determine the optimal n-6 to n-3 fatty acid ratio in relationship to health outcomes; investigate the conversion factor of α-linolenic acid to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and how n-6 intake competes with that conversion rate; compare the effects of EPA and DHA versus fish on lipid metabolism and other health outcomes; and determine the health effects of fish consumption on type 2 diabetes and cancer.

    Rationale: There are few studies comparing the effects of various n-6 to n-3 fatty acid ratios on lipid metabolism and other health outcomes. The impact of these polyunsaturated fatty acids on health needs to be examined in long-term studies of adults and children.

11. Compare the effects of various sources of *trans* fatty acids on lipid metabolism and health outcomes.

    Rationale: Research is needed to determine whether differences exist in the health effects of industrial versus animal sources of *trans* fat.

12. Investigate the effects of stearic acid intake on lipid metabolism and health.

    Rationale: Stearic acid has attracted interest as a substitute for *trans* fatty acids in prepared foods that require a solid fat. Stearic acid offers the functional properties needed for these foods, but the question arises of how it affects blood lipid values and indicators of cardiovascular disease.

13. Investigate the health benefits derived from the consumption of cereals, fruits, and/or vegetables; ascertain the biological mechanism whereby cereals, fruits, and vegetables alter disease risk; and determine the effects of fiber from these food sources on health (i.e., obesity and comorbidities).

    Rationale: Clinical trials and, if possible, dose-response studies are needed to expand our understanding of the health benefits associated with cereals, fruits, and vegetables and to determine whether those benefits are related to the fiber content of these foods and/or other components.

14. Investigate the implications of the intake of bottled water on fluoride intake and on health outcomes (especially oral health).

    Rationale: Most bottled water is not fluoridated. With the dramatic increase in consumption of bottled water, there is concern that the public may not be getting enough fluoride for maintenance or oral health.

15. Compare the effects of foods and beverages that contain added sugars and those that naturally contain sugar on body adiposity and other indicators of health in children and adults.

    Rationale: Studies are needed to determine the impact of different types of sugar on human health.

16. Compare calcium salts that provide equivalent amounts of calcium to that in milk and milk alternatives (i.e., calcium-fortified soy products) on bone health, insulin resistance, blood pressure, and weight management.

    Rationale*:* There are very few studies that compare sources of calcium and their impact on bone health, energy metabolism, insulin resistance, and blood pressure.

17. Investigate the role of increased total fluid intake as a means to prevent chronic diseases.

    Rationale: The IOM report identified a few studies suggesting that increased fluid consumption is associated with a reduced risk of bladder cancer, urinary tract infections,

kidney stones, and colon cancer. However, this evidence was insufficient to make recommendations on fluid intake.

18. Conduct trials that assess the effects of salt intake on clinical outcomes other than blood pressure.

    Rationale: Numerous studies have documented a direct relationship between salt intake and other outcomes, including urinary calcium excretion and left ventricular hypertrophy. In view of these findings, trials with clinically relevant outcomes, such as bone mineral density or left ventricular mass, are needed.

19. Conduct trials that test whether increased potassium intake or potassium-rich foods increase bone mineral density.

    Rationale: A consistent body of evidence from observational studies indicates that increased intake of potassium from foods is associated with greater bone mineral density and with evidence of reduced bone turnover. Data from small trials also have documented that increased intake of potassium reduces bone turnover.

20. Conduct dose-response trials that test the main and interactive effects of sodium and potassium intake on blood pressure and other clinically relevant outcomes.

    Rationale: There remains a need for dose-response trials, particularly for potassium, that span a clinically relevant range of dietary intake. Also, the interactive effects of sodium and potassium are of considerable interest.

21. Investigate the relationship between moderate alcohol consumption and obesity.

    Rationale: The data on the relationship between alcohol consumption and weight gain and/or obesity are inconclusive. Consumption of one or two drinks per day is associated with increased caloric intake. However, there is no apparent association between consuming one or two drinks a day and obesity.

22. Investigate the impact of adding calorie information to the labels of alcoholic beverages, including whether, for educational purposes, it would be sufficient to include only calories (i.e., not nutrients).

    Rationale: The caloric content of alcoholic beverages varies widely. Consumers do not have easy access to this information. Since alcoholic beverages provide calories and few nutrients, a more detailed label may not contribute useful information.

23. Investigate the impact of banning alcohol advertising when and where it might increase underage drinking (e.g., during college sports events).

    Rationale: Underage drinking is a major problem in the United States, and effective strategies to decrease the problem are needed.

24. Investigate the impact of unified Federal messages on alcohol and health through increased collaboration across agencies or consolidation of authority under one Federal agency.

    Rationale: With diverse groups responsible for messages on ethanol and health and with a variety of audiences, a consistent message has been difficult to achieve. Increased collaboration or consolidation would provide a unified message and have the potential to increase knowledge and promote healthful attitudes and behaviors related to alcohol consumption.

25. Investigate the effects of different types of cleaning on various surfaces. This research requires quantification of the type and counts of bacteria likely to be present on the surface before and after cleaning.

    Rationale: Food safety guidance needs to be continually updated as food consumption and preparation practices change and new pathogens emerge or adapt and change. Currently, insufficient data exist to clearly quantify the types and counts of bacteria likely to be present on surfaces before and after cleaning; such information is needed to set priorities for consumers.

26. Conduct research to improve methods to assess the risk of food safety (or the health benefits of a food) versus other factors (i.e., environmental contaminants of fish).

    Rationale: As scientific technology grows, risk assessment methods become more important in the complex task of prioritizing public health issues and communicating key safety messages. When providing food safety information to consumers, it is important that they understand the message. This requires knowledge of the risk assessment of food safety versus other factors (i.e., environmental contaminants in fish). This knowledge allows the consumer to prioritize various messages, which can be weighed, based on science. In this way, the information critical to food safety can be conveyed so that the consumer does not have an inordinate number of other issues to consider.

27. Conduct consumer research to evaluate food safety messages and corresponding changes in behavior.

    Rationale: Changing lifestyles have increased the need to assist consumers in recognizing the symptoms and sources of foodborne disease so that corrective action can be taken.

Part G: Appendices

Appendix G-1: Glossary of Terms

Acceptable Macronutrient Distribution Range (AMDR)—Range of intake for a particular energy source that is associated with reduced risk of chronic disease while providing intakes of essential nutrients. If an individual consumes in excess of the AMDR, there is a potential of increasing the risk of chronic diseases and/or insufficient intakes of essential nutrients. (IOM, 2003)

Added Sugars—Sugars and syrups that are added to foods during processing or preparation. Added sugars do not include naturally occurring sugars such as lactose in milk or fructose in fruits.

Adequate Intake (AI)—A recommended average daily nutrient intake level based on observed or experimentally determined approximations or estimates of mean nutrient intake by a group (or groups) of apparently healthy people. This is used when the Recommended Dietary Allowance cannot be determined. (IOM, 2003)

Atherogenic Dyslipidemia—Three lipid abnormalities: elevated triglycerides, small low-density lipoprotein particles, and reduced high-density lipoprotein cholesterol.

Calorie Compensation (or Energy Compensation)—The ability to regulate energy intake with minimal conscious effort, such as reducing the amount of food consumed on some occasions to compensate for increased consumption at other times.

Complex Carbohydrates—Large chains of sugar units arranged to form starches and fiber. Complex carbohydrates include vegetables, whole fruits, rice, pasta, potatoes, grains (brown rice, oats, wheat, barley, corn), and legumes (chick peas, black-eyed peas, lentils, as well as beans such as lima, kidney, pinto, soy, and black beans).

Daily Food Intake Pattern—Identifies the types and amounts of foods that are recommended to be eaten each day and that meet specific nutritional goals. (*Federal Register* notice, vol. 68, no. 176, p. 53536, Thursday, September 11, 2003)

Danger Zone—The temperature that allows bacteria to multiply rapidly and produce toxins, between 40°F and 140°F. To keep food out of this "danger zone," keep cold food cold and hot food hot. Keep food cold in the refrigerator, in coolers, or on ice in the service line. Keep hot food in the oven, in heated chafing dishes, or in preheated steam tables, warming trays, and/or slow cookers. Never leave perishable foods, such as meat, poultry, eggs, and casseroles, in the "danger zone" more than 2 hours (or 1 hour in temperatures above 90°F).

Deodorization—A process that uses high-vacuum and superheated steam in the washing of fats and oils. Deodorization removes from fats and oils materials originally present or introduced during previous processing that would contribute objectionable flavors and odors to the finished products. (United Soybean Board, The Soy Glossary)

Dietary Fiber—Nondigestible carbohydrates and lignin that are intrinsic and intact in plants.

Dietary Reference Intakes (DRIs)—A set of nutrient-based reference values that expand upon and replace the former Recommended Dietary Allowances (RDAs) in the United States and the Recommended Nutrient Intakes (RNIs) in Canada. They are actually a set of four reference values: Estimated Average Requirements (EARs), RDAs, AIs, and Tolerable Upper Intake Levels (ULs). (IOM, 2003)

Discretionary Calories—The balance of calories remaining in a person's "energy allowance" after consuming sufficient nutrient-dense forms of foods to meet all nutrient needs for a day. Discretionary calories may be used in selecting forms of foods that are not the most nutrient dense (e.g., whole milk rather than fat-free milk) or may be additions to foods (e.g., salad dressing, sugar, butter). A person's

energy allowance is the calorie intake at which weight maintenance occurs.

Energy Density—The calories contained in 100 grams of a particular food defines that food's energy density.

Estimated Average Requirement—EAR is the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group. (IOM, 2003)

FightBAC!—A national public education campaign to promote food safety to consumers and educate them on how to handle and prepare food safely. In this campaign, pathogens are represented by a cartoon-like bacteria character named "BAC."

Foodborne Disease—Caused by consuming contaminated foods or beverages. Many different disease-causing microbes, or pathogens, can contaminate foods, so there are many different foodborne infections. In addition, poisonous chemicals, or other harmful substances, can cause foodborne diseases if they are present in food. The most commonly recognized foodborne infections are those caused by the bacteria *Campylobacter*, *Salmonella*, and *E. coli* O157:H7, and by a group of viruses called calicivirus, also known as the Norwalk and Norwalk-like viruses.

Food Pattern Modeling—The process of developing and adjusting daily intake amounts from each food group and subgroup to meet specific criteria. The criteria may be meeting nutrient intake goals, limitations by food component (such as limiting saturated fats), or limiting or eliminating certain types of foods (such as no meats or no legumes). (Foote JA et al. Dietary variety increases the probability of nutrient adequacy among adults. *Journal of Nutrition* 134, 2004)

Functional Fiber—Isolated, nondigestible carbohydrates that have beneficial physiological effects in humans.

Glycemic Index—A classification proposed to quantify the relative blood glucose response to carbohydrate-containing foods. Operationally, it is the area under the curve for the increase in blood glucose after the ingestion of a set amount of carbohydrate in a food (e.g., 50 grams) during the 2-hour postprandial period relative to the same amount of carbohydrate from a reference food (white bread or glucose) tested in the same individual under the same conditions using the initial blood glucose concentration as a baseline.

Glycemic Load—An indicator of glucose response or insulin demand that is induced by total carbohydrate intake. It is calculated by multiplying the weighted mean of the dietary glycemic index by the percentage of total energy from carbohydrate.

Glycemic Response—The effects that carbohydrate-containing foods have on blood glucose concentration during the digestion process.

Glycerol—A three-carbon substance that forms the backbone of fatty acids in fats.

High-Fructose Corn Syrup (HFCS)—A corn sweetener derived from the wet milling of corn. Cornstarch is converted to a syrup that is nearly all dextrose. Enzymes isomerize the dextrose to produce a 42 percent fructose syrup called HFCS-42. By passing HFCS-42 through an ion-exchange column that retains fructose, corn refiners draw off 90 percent HFCS and blend it with HFCS-42 to make a third syrup, HFCS-55. HFCS is found in numerous foods and beverages on the grocery store shelves. HFCS-90 is used in natural and "light" foods in which very little is needed to provide sweetness (ERS, USDA). Total fiber is the sum of dietary fiber and functional fiber.

Hydrogenation—A chemical reaction that adds hydrogen atoms to an unsaturated fat, thus saturating it and making it solid at room temperature.

Leisure-Time Physical Activity—Physical activity that is performed during exercise, recreation, or any additional time other than that associated with one's regular job duties, occupation, or transportation. (CDC)

Lifestyle Physical Activity—Muscle-powered movement performed as a part of day-to-day activities, such as transportation (e.g., walking to work), household chores (e.g., yard work), or childcare (e.g., playing actively with children).

Listeriosis—A serious infection caused by eating food contaminated with the bacterium *Listeria monocytogenes*, which has recently been recognized as an important public health problem in the United States. The disease affects primarily pregnant women, their fetuses, newborns, and adults with

weakened immune systems. *Listeria* is killed by pasteurization and cooking; however, in certain ready-to-eat foods, such as hot dogs and deli meats, contamination may occur after cooking/manufacture but before packaging. *Listeria monocytogenes* can survive at refrigerated temperatures.

Macronutrient—The three macronutrient groups are carbohydrates, protein, and fat.

Metabolic Equivalent (MET)—A way of measuring physical activity intensity. This unit is used to estimate the amount of oxygen used by the body during physical activity (Ainsworth, 1993). 1 MET = the energy (oxygen) used by the body when sitting quietly, perhaps while talking on the phone or reading a book. The harder the body works during the activity, the higher the MET.

Metabolic Syndrome—A collection of metabolic risk factors in one individual. The root causes of metabolic syndrome are overweight/obesity, physical activity, and genetic factors. Various risk factors have been included in metabolic syndrome. Factors generally accepted as being characteristic of this syndrome include abdominal obesity, atherogenic dyslipidemia, raised blood pressure, insulin resistance with or without glucose intolerance, prothrombotic state, and proinflammatory state.

Micronutrient—An essential nutrient, as a trace mineral or vitamin, that is required by an organism in minute amounts.

Moderate Physical Activity—Any activity that burns 3.5 to 7 kcal/min or the equivalent of 3 to 6 metabolic equivalents (METs) (CDC) and results in achieving 60 to 73 percent of peak heart rate (ASCM). An estimate of a person's peak heart rate can be obtained by subtracting the person's age from 220. Examples of moderate physical activity include walking briskly, mowing the lawn, dancing, swimming, or bicycling on level terrain. A person should feel some exertion but should be able to carry on a conversation comfortably during the activity. (CDC)

Nutrient Adequacy—A goal based on the RDA or AI set by the IOM in recent Dietary Reference Intake reports. Goals include targets for vitamins, minerals, and macronutrients and acceptable intake ranges for macronutrients for various age/gender groups. Adequacy of intake relates to meeting the individual's requirement for that nutrient. (Modified from the Dietary Reference Intakes—Applications in Dietary Assessment, IOM, p. 254, 2000)

Nutrient Density—Nutrient-dense foods are those that provide substantial amounts of vitamins and minerals and relatively few calories. Foods that are low in nutrient density are foods that supply calories but relatively small amounts of micronutrients (sometimes not at all). (Modified from the International Food Information Council [IFIC] Glossary of Food-Related Terms at *www.ific.org/glossary/glossarynz.cfm.*)

Pathogen—Any microorganism that can cause or is capable of causing disease.

Phytochemicals—Substances found in edible fruits and vegetables that may be ingested by humans daily in gram quantities and that exhibit a potential for modulating the human metabolism in a manner favorable for reducing the risk of cancer. (Modified from the IFIC Glossary of Food-Related Terms at *www.ific.org/glossary/glossarynz.cfm.*)

Portion Size—The amount of a food served in one eating occasion.

Probability of Adequacy—The probability that a given nutrient intake is adequate for an individual can be calculated if the requirement distribution is known. If this distribution is approximately normal, it is defined by the Estimated Average Requirement (EAR) and its standard deviation.

Prothrombotic State—Any condition that predisposes to venous or arterial thrombosis (formation or presence of a clot within a blood vessel).

Recommended Dietary Allowance (RDA)—The dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group. (IOM, 2003)

Resistance Training—Anaerobic training, including weight training, weight machine use, and resistance band workouts. Resistance training will increase your strength, muscular endurance, and muscle size; running and jogging will not.

Salmonellosis—An infection caused by bacteria called *Salmonella*. Most persons infected with *Salmonella* develop diarrhea, fever, and abdominal cramps 12 to 72 hours after infection. The illness usually lasts 4 to 7 days, and most people recover without treatment. Salmonellosis is prevented by cooking poultry, ground beef, and eggs thoroughly before eating and not eating or drinking foods containing raw eggs or raw unpasteurized milk.

Sedentary Behavior—In scientific literature, sedentary is often defined in terms of little or no physical activity during leisure time. A sedentary lifestyle is a lifestyle characterized by little or no physical activity. (CDC)

Sensory-Specific Satiety—The difference between the palatability change score for the food that is eaten versus the score for the food that is uneaten.

Serving Size—A standardized amount of a food, such as a cup or an ounce, used in providing dietary guidance or in making comparisons among similar foods.

Simple Carbohydrates—Sugars composed of a single sugar molecule (monosaccharide) or two joined sugar molecules (a disaccharide), such as glucose, fructose, lactose, and sucrose. Simple carbohydrates include white and brown sugar, fruit sugar, corn syrup, molasses, honey, and candy.

Structured Exercise—Physical activity performed in a planned manner for enhancing health and/or fitness.

Tolerable Upper Intake Level (UL)—The highest average daily nutrient intake level likely to pose no risk of adverse health affects for nearly all individuals in a particular life stage and gender group. As intake increases above the UL, the potential risk of adverse health affects increases. (IOM, 2003)

Vigorous Physical Activity—Any activity that burns more than 7 kcal/ min or the equivalent of 6 or more METs (CDC) and results in achieving 74 to 88 percent of peak heart rate (ASCM). An estimate of a person's peak heart rate can be obtained by subtracting the person's age from 220. Examples of vigorous physical activity include jogging, mowing the lawn with a nonmotorized push mower, chopping wood, participating in high-impact aerobic dancing, swimming continuous laps, or bicycling uphill. Vigorous-intensity physical activity may be intense enough to represent a substantial challenge to an individual and results in a significant increase in heart and breathing rate. (CDC)

Weight-Bearing Exercise—Any activity one performs that works bones and muscles against gravity, including walking, running, hiking, dancing, gymnastics, and soccer.

Whole-Grain Foods—Foods made from the entire grain seed, usually called the kernel, which consists of the bran, germ, and endosperm. If the kernel has been cracked, crushed, or flaked, it must retain nearly the same relative proportions of bran, germ, and endosperm as the original grain to be called whole grain. (ACCC, 2004)

Appendix G-2: Original Food Guide Pyramid Pattern and Description of USDA Analyses

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Note that the reports are presented as analyzed and submitted, using the food intake pattern that was current at the time the analysis was conducted. Data have not been updated to reflect later modifications to the pattern to increase potassium levels.

Food Guide Pyramid as it Appeared in the *2000 Dietary Guidelines for Americans*

(number of servings recommended daily from each food group at three calorie levels)

Food Group	**Children Age 2 to 6 Years, Women, Some Older Adults (about 1,600 calories)**	**Older Children, Teen Girls, Active Women, Most Men (about 2,200 calories)**	**Teen Boys, Active Men (about 2,800 calories)**
Bread, cereal, rice, and pasta group (grains group)	6	9	11
Vegetable group	3	4	5
Fruit group	2	3	4
Milk, yogurt, and cheese group (milk group)—preferably fat-free or low-fat	2 or 3*	2 or 3*	2 or 3*
Meat, poultry, fish, dry beans, eggs, and nuts group (meat and beans group)—preferably lean or low fat	2, for a total of 5 ounces	2, for a total of 6 ounces	3, for a total of 7 ounces

*The number of servings depends on your age. Older children and teenagers (age 9 to 18 years) and adults age 50 years and older need three servings daily. Others need two servings daily. During pregnancy and lactation, the recommended number of milk group servings is the same as for nonpregnant women.

Source: Nutrition and Your Health: *Dietary Guidelines for Americans*, 5th ed. USDA and HHS, 2000.

Lacto-Ovo Vegetarian Food Intake Pattern Analysis—May 21, 2004

Request From the Nutrient Adequacy Subcommittee

How can the food intake pattern be modified for vegetarians and still meet nutritional goals?

Background

The Pyramid food intake pattern has grouped animal and plant protein sources into a single food group—the meat, poultry, fish, eggs, and nuts (MPFEN) group. The nutrient profile of this group was previously calculated assuming a proportionate intake of each food category equal to the proportion consumed by the population. The meats and poultry selected as representative items were the leanest choices within each food type. Food items selected in calculating the nutrient profile were those whose intake represents more than 1 percent of the total intake of the food group. Other foods (with less than 1 percent intake) in each category were grouped with the most similar food in calculating overall percentage consumption. Legumes also are recognized as an important plant protein source, but they have traditionally been grouped with other vegetables and are included as a separate vegetable subgroup in the food intake pattern.

Ounce equivalencies used in the MPFEN nutrient profiles were originally determined by identifying amounts of eggs and nuts that approximate the nutrient content of 1 ounce of meat, poultry, and fish. Protein content was the prime nutrient considered. A comparison of the nutrients in 1-ounce equivalent of each type of food in the group is shown in Addendum A.

While the number of vegetarians has increased markedly since the original development of the food pattern, there is still insufficient data on their food intake to develop a totally separate food intake pattern for them. Therefore, it has been assumed that vegetarians could use the food intake pattern, selecting only protein sources from the MPFEN group that are acceptable to them and including additional legumes. The adequacy of this approach has never been fully explored, however. This analysis is intended to determine if lacto-ovo vegetarians can use the food intake pattern to select an adequate diet; to identify appropriate ratios of legumes, nuts, and eggs to meet nutrient needs; and to see what additional modifications in their food choices would be necessary.

Methods

1. Used the proposed food intake pattern (with updated intake recommendations to increase potassium) and nutrient profiles based on 1999–2000 NHANES consumption data and the SR 16-1 nutrient data as the basis for this analysis.
2. Modified the composition of the MPFEN nutrient profile to include only eggs, nuts, and legumes (ENL). (Legumes were added to the profile.) Determined the changes in nutrient and calorie levels with varying proportions of these foods in the new vegetarian ENL nutrient profile. Note that no attempt was made to base the proportions of ENL on actual intakes. (A qualitative assessment of the "reasonableness" of the proportions was made, however.) Amounts from the milk group were left unchanged, with 2 or 3 cups of milk per day in the intake pattern.
3. Using the adjusted nutrient profiles for a vegetarian ENL group, analyzed the adequacy of the resulting food pattern. Adjusted proportions and amounts of ENL in the nutrient profiles iteratively to meet nutrient needs within set calorie levels.
4. Assessed amounts of absorbed iron available in the vegetarian ENL food intake pattern by calculating absorbed iron using non-heme percent absorption.
5. Assessed adequacy of limiting essential amino acids in the vegetarian ENL food intake pattern. Addendum B also provides additional general information on protein in vegetarian diets.
6. Calculated recommended intakes for ENL in the vegetarian pattern in food equivalents per day or per week for 5-, 6-, and 7-ounce equivalent intake levels.

Results

1. Table G2-1 shows the original food subgroups used in developing the MPFEN food group, the percent of the total composite for each, and actual amounts this translates into in a food pattern that suggests 5-ounce equivalents per day from this group (the 1,600- or 1,800-calorie pattern). The percents are based on NHANES 1999–2000 consumption data for each subgroup.

Table G2-1. Original MPFEN Group and Amounts Recommended

Subgroups in the Original MPFEN Group	Percent of MPFEN Consumption	Amount in a Daily Food Pattern With 5-oz. eq. From Group
Meats (beef, ground beef, pork, lamb, ham, luncheon meats, and liver item groups)	55.7%	2.79 oz.
Poultry (chicken and turkey item groups)	24.5%	1.23 oz.
Fish (originally lean finfish, fatty finfish, tuna, and shellfish item groups*)	8.3%	0.42 oz.
Eggs	7.8%	0.39 eggs
Nuts and seeds	3.6%	0.18-oz. eq. [†]

*See report on increasing fish consumption for new fish item groups now being used in analyses.

[†]Equal to approximately 0.27 ounces of nuts or 0.38 tbsp of peanut butter.

A separate nutrient profile had been developed previously for each subgroup in the MPFEN group and for legumes. Addendum A shows these nutrient profiles. To determine appropriate amounts of ENL to use in the vegetarian pattern, nutrient differences among these foods were examined. Nuts and legumes contain more calories per ounce equivalent than meat, poultry, or fish. The weighted average number of calories in each is 210 per 1-oz. eq. of nuts, 113 per 1-oz. eq. of legumes, 51 per oz. of meat, 53 per oz. of poultry, and 39 per oz. of fish. To develop the isocaloric food intake pattern, the differences in energy levels were compensated for by decreasing overall amounts, including fewer ounce equivalents than are in the original MPFEN pattern. Amounts were decreased iteratively to lower caloric levels, using varying proportions from ENL, until a nutrient intake level became marginal in at least one pattern. Because so many nutrients are provided in amounts above the recommended standards, it was possible to meet most nutrient needs with lower intakes of ENL and to come close to an isocaloric food pattern. Also, iron, a limiting nutrient, is provided in high amounts by legumes. (See #4 below for a discussion of absorbed iron intakes.)

2. Through these iterations, a vegetarian ENL group was developed that, with very limited exceptions, met all vitamin/mineral/ macronutrient requirements at all 12 calorie levels. Table G2-2 illustrates the resulting percentage composition and amounts in the ENL group. Note that no attempt was made to base the proportions of ENL on actual intakes. The percentages and amounts in Table G2-2 represent the amounts of ENL substituted for the MPFEN pattern. Since amounts of each were decreased to maintain the isocaloric food pattern, the total percentages in the table do not total to 100 percent, and the amounts in the 5-oz. eq. daily food pattern do not total to 5 ounces. This was done so that the percentages and ounce equivalents in Table G2-2 could be compared directly with Table G2-1.

Table G2-2. Vegetarian ENL Group and Amounts Recommended

Subgroups in the Vegetarian ENL Group	Percent of Each Subgroup in ENL Group*	Amount in a Daily Food Pattern With 5-oz. Eq. From Group
Meats	0%	0
Poultry	0%	0
Fish	0%	0
Eggs	7.8%	0.39 eggs
Nuts and seeds	16.0%	0.80 oz. eq.*
Legumes	23.0%	1.15 oz. eq.[†]

*Equal to approximately 1.2 ounces of nuts or 1.6 tbsp. of peanut butter.

[†]Equals about 0.58 cups of cooked legumes. Total legumes, including amounts recommended in the vegetable group, are about 1 cup.

Table G2-3. Vegetarian ENL Nutrient Profile (Absolute Changes From the Original MPFEN Nutrient Profile Based on 5-Oz. Eq. Daily Intake Level)

Vitamins	**Change From MPFEN Profile**	**Minerals**	**Change From MPFEN Profile**	**Energy and Macro-Nutrients**	**Change From MPFEN Profile**
Vitamin A	–55 μg RAE	Calcium	+66 mg	Calories	+36 kcal
Vitamin E	+2.18 mg AT	Phosphorus	–27 mg	Protein	–20 g
Vitamin C	+0.5 mg	Magnesium	+59 mg	Carbohydrate	+25 g
Thiamin	–0.11mg	Iron	+0.71 mg*	Fiber	+8.2 g
Riboflavin	–0.19 mg	Zinc	–2.48 mg	Linoleic acid	+3.19 g
Niacin	–5.36 mg	Copper	+0.33 mg	α-linolenic acid	+0.06 g
Vit. B_6	–0.36 mg	Sodium	–441 mg	Cholesterol	–8 g
Folate	+139 μg	Potassium	+83 mg	Total fat	+4.17 g
Vit. B_{12}	–2.59 μg			Sat. fat	–0.87 g
				Mono. fat	+2.22 g
				Poly. fat	+3.05 g

*Does not account for differences in absorption (see #4).

The proposed vegetarian ENL group differs somewhat from the original MPFEN group in nutrient content. Table G2-3 summarizes the differences in the ENL group from the original MPFEN group in absolute terms, based on an assumed intake level of 5-oz. eq. per day. Actual nutrient levels in the original MPFEN group and in the ENL group are found in Addendum A.

As illustrated in Table G2-3, there was a 36-calorie-per-day increase in the energy content ofthe vegetarian ENL group, compared with the original MPFEN group, in the food pattern, including a 5-oz. eq. from the group per day. This was due to the amounts of nuts and legumes, which have higher calorie-to-protein ratios than animal-based protein sources. (Addendum A provides a comparison of all nutrients in per oz. eq. of these foods.) To maintain the isocaloric pattern, the vegetarian food pattern could be modified by slightly adjusting the amounts of added sugars, solid fats, and oils. This modification was not completed since the difference was small (from about 14 calories in the 1,000-calorie pattern to about 50 calories in the 3,200-calorie pattern).

Differences in the amounts of protein, niacin, zinc, and vitamin B_{12} that could have an impact on nutrient adequacy were also noted. Adequacy of these nutrients was evaluated in the pattern, as reported below.

3. The lacto-ovo vegetarian pattern that was developed in this scenario, with limited exceptions, met vitamin/mineral/macronutrient requirements at all 12 calorie levels for all age/sex groups. Table G2-4 shows amounts of the nutrients of concern that were identified above in the selected food intake pattern. It also includes other nutrients that have been of concern, vitamin E and potassium. Iron is reported separately in Table G2-5. The intake pattern in the table is that with the lowest nutrient intake level.

Table G2-4. Nutrients of Concern in the ENL Food Intake Pattern

Nutrient	Food Pattern	Age-Sex Group (sedentary)	MPFEN Patterns—Amount in Pattern as % of Nutritional Goal	ENL Vegetarian Patterns—Amounts in Pattern as % of Nutritional Goal
Protein	1800 (2m)	F 31-50	180%	137%
	2000 (3m)	M 51-70	171%	132%
	2200 (2m)	M 31-50	170%	127%
Niacin	1600 (3m)	F 51-70	140%	101%
	1800 (2m)	F 31-50	152%	113%
	1800 (3m)	F 14-18	153%	114%
	2200 (3m)	M 14-18	162%	105%
Zinc	2000 (3m)	M 51+	128%	105%
	2200 (2m)	M 31-50	131%	105%
Vitamin B_{12}	1800 (2m)	F 31-50	265%	157%
	2000 (2m)	F 19-30	277%	158%
	2200 (2m)	M 31-50	295%	166%
Vitamin E	1600 (3m)	F 51-70	49%	64%
	1800 (2m)	F 31-50	55%	70%
	1800 (3m)	F 14-18	55%	70%
Potassium*	1000 (2m)	M/F 2-3	68%	70%
	1200 (2m)	F 4-8	66%	68%
	1400 (2m)	M 4-8	77%	79%
	1800 (2m)	F 31-50	83%	85%
	2000 (2m)	F 19-30	85%	87%

*Based on energy-adjusted standards for potassium.

In addition to iron, the other nutrient that became limiting as amounts of ENL were adjusted was niacin. Poultry and fish are especially rich in niacin, and nuts are also a rich source but at a higher calorie "cost." Amounts in the pattern decreased substantially, with amounts in the 1,600-calorie pattern just above the Recommended Dietary Allowance (RDA) in the final iteration.

Amounts of vitamin B_{12} also dropped dramatically, but all levels remained above the RDA. For vitamin E, the higher levels found in nuts made a substantial increase in the amounts in each pattern. The pattern at or above 2,800 calories met the RDA for vitamin E.

Other interesting changes in the pattern included the following:

- Vitamin A levels fell about 10 percent (for example, from 170 to 160 percent of the RDA), but remained adequate.
- Calcium levels rose slightly (about 5 percent of the Adequate Intakes [AI]), but the bioavailability of this calcium may be lower.
- Magnesium levels rose by 15 to 20 percent of the RDA.
- Sodium levels fell substantially. (Note that all legumes in the pattern are without added salt, while some luncheon meats that are higher in sodium are included in the MPFEN pattern.)
- Fiber levels rose by about 33 percent of the AI.
- Cholesterol levels fell substantially.
- Carbohydrates (as a percentage of calories) rose from the previous 55 to 59 percent to 59 to 63 percent of calories, and total fat rose slightly from the previous 27 to 29 percent to 28 to 30 percent of calories. Protein (as a percent of calories) decreased from 15 to 19 percent to 11 to 15 percent.
- Saturated fat (as a percent of calories) fell slightly from 6.9 to 7.7 percent to 6.4 to 7.2 percent (excluding the 1,000-calorie pattern).

4. Amounts of iron in the pattern proved to be the most limiting, especially when differences in percent absorption were considered. The *Dietary Reference Intakes* (DRI) report on iron includes a formula for calculating iron absorbed from a mixed diet, assuming 10 percent of overall iron is from heme sources. Heme iron absorption is assumed at 25 percent, and non-heme iron at 16.8 percent. The overall absorption from a mixed diet is then calculated to be 17.6 percent. Table G2-5 shows the levels of iron in the vegetarian pattern up to 2,400 calories and the amount of absorbed iron expected in each pattern based on these assumed rates of absorption.
5. Analysis of the vegetarian ENL food pattern demonstrated that lysine, which is considered the most limiting essential amino acid in vegetarian diets, met or exceeded the RDAs for all age/sex groups. These levels were met by considering the protein available in both animal (eggs and milk) and plant (nuts, legumes, grains) products in the proposed ENL pattern. Based on our lysine analysis, it is unlikely that any of the other eight essential amino acids would be limiting, below their RDA, or of concern to those following the ENL food pattern.
6. The final ENL amounts were translated into daily/weekly intake recommendations at three intake levels, as shown in Table G2-6. For legumes, the amounts recommended as part of the vegetable group were added to the amount that is part of the ENL group to show total suggested intake levels per day and per week, in cups. For eggs, the suggested intake levels are shown as eggs per day and per week. For nuts, intakes are shown as ounces of nuts or tablespoons of peanut butter per day and per week.

Discussion

The nutrient profile for legumes includes tofu, though in relatively small amounts. If vegetarians select more tofu and other soy-based meat analogs as part of their legume choices, the fiber content of the diet could be slightly lower, and other nutrients could be altered as well.

Table G2-5. Iron in the Vegetarian Pattern at Each Calorie Level in Comparison to Absorbed Iron Requirements for Appropriate Age/Sex Group

Calorie Level (cups of milk in pattern)	Age/Sex Group	Iron RDA (mg)	Absorbed Iron Requirement* (mg)	Iron in Food Pattern (mg)	Absorbed Iron in Pattern† (mg)	Percent of Requirement Met by Pattern (%)
1000 (2 milk)	M/F 1-3	7	1.23	8.0	1.34	109
1200 (2 milk)	F 4-8	10	1.76	11.0	1.85	105
1400 (2 milk)	M 4-8	10	1.76	13.1	2.20	125
1600 (3 milk)	F 9-13, 51-70	8	1.41	15.2	2.55	181
1800 (2 milk)	F 31-50	18	3.17	17.4	2.92	**92**
1800 (3 milk)	F 14-18	15	2.64	17.4	2.92	111
2000 (2 milk)	F 19-30	18	3.17	17.9	3.01	**95**
2000 (3 milk)	M 9-13, 51-70	8	1.41	18.0	3.02	215
2200 (2 milk)	M 31-50	8	1.41	20.2	3.39	241
2200 (3 milk)	M 14-18	11	1.94	20.3	3.41	176
2400 (2 milk)	M 19-30	8	1.41	22.0	3.70	262

* Calculated from DRI formula for mixed diet; factor = 0.176.

†Calculated from % non-heme absorption; factor = 0.168.

Table G2-6. Daily and Weekly Intake Recommendations for the ENL Intake Pattern

Food/Intake Pattern	Calculated Oz. Eq./Day	Suggested Intake/Day	Suggested Intake/Week
Eggs			
1800 kcal	0.74	~¾ eggs	~5 eggs
2200 kcal	0.89	~1	~6
2800 kcal	1.04	~1	~7
Nuts			
1800 kcal	0.80	~1¼ ounces nuts OR ~1½ T. peanut butter	~8 ounces nuts OR ~11 T. peanut butter
2200 kcal	0.96	~1½ ounces nuts OR ~2 T. peanut butter	~10 ounces nuts OR ~13 T. peanut butter
2800 kcal	1.12	~1¾ ounces nuts OR ~2¼ T. peanut butter	~12 ounces nuts OR ~16 T. peanut butter
Legumes			
1800 kcal			
— from ENL grp.	1.15		
— from vegetable	0.86		
— total	2.01	~1 cup	~7 cups
2200 kcal			
— from ENL grp.	1.38		
— from vegetable	0.86		
— total	2.44	~1⅛ cup	~8 cups
2800 kcal			
— from ENL grp.	1.61		
— from vegetable	1.00		
— total	2.61	~1⅓ cup	~9 cups

Addendum A:
Nutrient Profiles of the MPFEN and ENL Groups and Their Component Foods

Nutrient	MPFEN 1 oz. eq.	ENL 1 oz. eq.	Meat 1 oz.	Poultry 1 oz.	Fish 1 oz.	Eggs 1 large egg	Nuts 1 oz eq.	Legumes 1 oz eq.
Vitamins								
Vit. A (µg Rae)	17.64	6.62	16.64	4.21	8.61	84.5	0.149	0.03
Vit. E (mg At)	0.21	0.65	0.07	0.08	0.14	0.53	2.98	0.58
Vit. C (mg)	0.03	0.12	0.01	0.00	0.21	0.00	0.12	0.45
Thiamin (mg)	0.07	0.04	0.09	0.02	0.05	0.03	0.10	0.11
Ribofl. (mg)	0.08	0.04	0.07	0.05	0.05	0.26	0.05	0.05
Niacin (mg)	1.75	0.68	1.47	2.52	2.15	0.03	3.76	0.33
Vit. B6 (mg)	0.12	0.04	0.11	0.13	0.13	0.06	0.12	0.08
Folate (µg)	5.12	33.04	2.47	1.72	3.57	22.00	36.39	110.87
Vit. B12 (µg)	0.56	0.04	0.78	0.09	0.72	0.56	0.00	0.00
Minerals								
Calcium (mg)	6.16	19.32	2.89	4.46	5.74	25.00	28.43	55.76
Phosph. (mg)	65.74	60.35	62.09	55.65	55.92	86.00	170.14	114.86
Magnesium (mg)	8.84	20.74	6.46	7.11	9.12	5.00	65.28	43.08
Iron (mg)	0.57	0.71	0.65	0.35	0.49	0.60	0.90	2.25
Zinc (mg)	1.05	0.56	1.38	0.62	0.30	0.53	1.80	0.99
Copper (mg)	0.06	0.12	0.05	0.02	0.05	0.01	0.43	0.23
Sodium (mg)	106.97	18.82	160.12	24.05	49.98	62.00	78.46	6.22
Potassium (mg)	97.19	113.78	105.36	70.02	102.19	63.00	219.27	320.79
Energy and Macronutrients								
Calories (Kcals)	58	66	51	53	39	78	210	113
Protein (g)	7.56	3.62	7.56	8.21	6.57	6.29	8.09	7.99
Carbohydrate (g)	0.47	5.45	0.32	0.00	0.00	0.56	6.81	18.78
Fiber (g)	0.09	1.74	0.00	0.00	0.00	0.00	2.56	5.79
Linoleic Acid (g)	0.40	1.04	0.091	0.38	0.06	0.59	5.66	0.37
α-Linolenic Acid (g)	0.03	0.04	0.03	0.02	0.04	0.02	0.07	0.11
Cholesterol (mg)	36	17	20	25	27	212	0	0
Total Fat (g)	2.77	3.60	1.95	2.05	1.22	5.31	18.44	1.04
Sat. Fat (g)	0.82	0.65	0.76	0.57	0.23	1.63	3.01	0.16
Mono. Fat (g)	1.16	1.61	0.85	0.72	0.44	2.04	8.78	0.19
Poly. Fat (g)	0.47	1.04	0.11	0.47	0.42	0.71	5.73	0.49

Addendum B: Protein in Vegetarian Diets

Several points regarding protein and amino acids in vegetarian diets follow:

- It is the position of the American Dietetic Association (ADA) and Dietitians of Canada that appropriately planned vegetarian diets are healthful, nutritionally adequate, and provide health benefits in the prevention and treatment of certain diseases (ADA and Dietitians of Canada, 2003).
- Well-planned vegetarian and vegan diets are appropriate for all stages of the life cycle, including during pregnancy, lactation, infancy, childhood, and adolescence (ADA and Dietitians of Canada, 2003).
- Available evidence does not support recommending a separate protein requirement for vegetarians who consume complementary mixtures of plant proteins (IOM, 2002).

Protein

- Plant protein can meet requirements when a variety of plant foods are consumed and energy needs are met (ADA and Dietitians of Canada, 2003).
- Vegetarian diets that include complementary mixtures of plant proteins can provide the same quality of protein as animal proteins (IOM, 2002).
- Typical protein intakes of lacto-ovo vegetarians and vegans appear to meet and exceed protein requirements. Athletes can also meet their protein needs on plant-based diets (ADA and Dietitians of Canada, 2003).
- Plant proteins are generally less digestible than animal proteins; however, digestibility can be altered through processing and preparation. Therefore, consuming a varied diet ensures an adequate intake of protein for vegetarians (IOM, 2002).

Essential Amino Acids

- There are nine essential amino acids: histidine, isoleucine, leucine, lysine, methionine (and/or cysteine), phenylalanine (and/or tyrosine), threonine, tryptophan, and valine.
- If a single essential amino acid in the diet is less than the individual's requirement, then it will limit the utilization of other amino acids and thus prevent normal rates of protein synthesis. Thus, the "limiting amino acid" will determine the nutritional value of the protein in the diet. In general, this is the most important factor that influences the nutritional value of a protein source (IOM, 2002).
- Protein from vegetarian-consumed animal products—such as eggs, milk, cheese, and yogurt—are "complete proteins" because they provide all nine essential amino acids (IOM, 2002).
- Protein from most plants, legumes, grains, nuts, seeds, and vegetables tend to be deficient in one or more essential amino acids and are called "incomplete proteins." Exceptions include soybeans, quinoa, and spinach. They are considered high-quality proteins because they contain adequate amounts of the essential amino acids (IOM, 2002; Vegetarian Resource Group, 2004).
- Wheat/cereals tend to be low in lysine, an essential amino acid. Increased consumption of beans and soy products in place of other protein sources that are lower in lysine—or an increase in dietary protein from all sources—can ensure an adequate intake of lysine (ADA and Dietitians of Canada, 2003).
- While lysine is likely to be the most limiting of the essential amino acids in diets based predominantly on cereal proteins, the risk of lysine inadequacy is essentially removed by the inclusion of relatively modest amounts of animal or other vegetable proteins, such as those from legumes and oilseeds or through lysine fortification of cereal flour (IOM, 2002).

Complementary Proteins

- Previously, it was thought that vegetarians had to consume all essential amino acids at the same meal—from a mixture of foods that together contained all nine—in order to consume the necessary "complete" protein. Research indicates that an assortment of plant foods eaten during 1 day can provide all essential amino acids and ensure adequate nitrogen retention and use in healthy adults; thus, complementary proteins do not need to be consumed at the same meal (ADA and Dietitians of Canada, 2003).

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Alternatives for Enriched Grains in the Food Intake Pattern—December 13, 2003

Request From the Nutrient Adequacy Subcommittee

Is it possible to offer more flexibility in the macronutrient composition of diets by not specifying the amount of enriched grains currently proposed in the Food Guide Pyramid (FGP) food pattern?

Rationale for Request

Since many of the nutrients enriched grains supply are easily met in the FGP pattern (thiamin, riboflavin, etc.), why not make them optional, like discretionary fat and added sugars, allowing people flexibility in the composition of their diet by replacing the calories from enriched grains with another food group or healthy oils, for example, in a lower carbohydrate diet?

Context for Examining Possible Changes in the Food Pattern

1. **Total vs. Foundation Diet Approach:** The FGP is a total diet system, which means that all calories must be accounted for in some way. This system differs fundamentally from a foundation diet, which ensures nutrient adequacy but allows free choice of any additional calories to meet energy needs. The free choice of some calories in a foundation diet approach is not compatible with moderation goals, such as limiting saturated fat intake. The total diet approach is used because some of the nutritional goals for the Pyramid specify ranges or maximum amounts rather than minimums. Also, specific calorie levels have been identified for various age/sex/activity level groups of people.

   Within a total diet system, flexibility of choice for the consumer is given where possible through choices within specific food categories. These food categories have similarities in their content of key nutrients, including their macronutrient composition. For example, the proposed food pattern for the Pyramid allows flexibility of choice within each food group or subgroup, and within the categories of additional solid fats, additional oils, and added sugars. Choices made within these categories maintain the overall nutritional profile of the diet.

2. **Defining "Optimal" Dietary Choices:** The Pyramid does not set nutritional policy—it is an educational tool designed to help Americans implement current policy on what constitutes an "optimal" diet. Operationally, an "optimal" diet is defined as meeting the current Dietary Guidelines and the DRI. Quantified nutritional goals for the Pyramid's food pattern are set based on these standards. In addition, educational messages are developed to provide additional guidance where qualitative but not quantified goals are available.

3. **Selection of One Set of "Optimal" Choices:** There are an immense number of food patterns that could meet current nutritional adequacy and moderation goals. How can one set of food choices be selected over another? The premise used in determining the food pattern for the Pyramid has been to start with what is actually consumed by Americans and adjust the amounts of various food categories (which include both "food groups" and "subgroups") into healthful proportions. Alterations are made in the amounts recommended from each category until nutrient goals (for adequacy and moderation) are met. Major shifts from actual consumption patterns may occur, but only if they are needed to meet the stated goals. This approach differs from some other food guidance approaches that use different criteria to identify other "optimal" dietary patterns.

Results of the Existing Process—How Does the Proposed Food Pattern Compare to Reported Food Consumption of Americans, Especially in Enriched Grain Intake?

For some food categories, the amounts recommended are more than current consumption, whereas for others the amounts recommended are less than consumption. Table G2-7 presents the amounts from each food group and subgroup *recommended* in the proposed food pattern. Table G2-8 presents the amounts *actually consumed* for each food group and subgroup as reported in the CSFII 1994–1996. Table G2-9 presents a *comparison* of the recommended amounts to the amounts that individuals in various age/sex groups report eating, as a percentage of reported consumption.

These tables show that the proposed Pyramid food pattern (from the *Federal Register* notice of September 11, 2003) includes substantial increases

over reported consumption for legumes, dark green leafy vegetables, deep yellow vegetables, and whole grains. Conversely, recommended amounts of enriched grains, starchy vegetables, added fats, and added sugars are reduced substantially from reported consumption.

For example, Table G2-9 shows the following findings for adult women age 31 to 50 years:

- The recommended intake of whole grains is 437 percent of reported consumption.
- The recommended intake of dark green vegetables is 431 percent of reported consumption.
- The recommended intake of enriched grains is 72 percent of reported consumption.
- The recommended intake of starchy vegetables is 68 percent of reported consumption.

Note that the percent change from reported to recommended intakes for the *overall* vegetable and grain groups are not large. However, shifts in recommended intakes *within* these groups result in substantial changes in each of the subgroups. In the grains group, these shifts from "enriched grains" to "whole grains" recommend a twofold to fivefold increase (across age/gender groups) in whole grain consumption and a decrease in enriched grains consumption to about ½ to ¾ of reported consumption. Changes of similar or greater magnitude also result among vegetable subgroups.

Results of Preliminary Analysis To Further Decrease Amounts of Enriched Grains in the Food Pattern

1. **Nutrients Supplied by the Enriched Grain Subgroup:** Enriched grain products contribute important amounts of certain nutrients to the Pyramid food pattern. For example, in the 1,800-calorie food pattern (with two milk servings), the contribution of "enriched grains" to the overall intake is

Folate	25 percent
Iron	24 percent
Calcium	9 percent
Magnesium	8 percent
Copper	12 percent
Dietary fiber	10 percent

   Enriched grains also supply 27 percent of the thiamin, 16 percent of the riboflavin, and 20 percent of the niacin in the food pattern, although these nutrients are provided in the overall pattern at levels well above the requirements. Enriched grains also supply 17 percent of the calories and 22 percent of the carbohydrate in this food pattern.

2. Shortfalls if Enriched Grains (But Not Whole Grains) Are Omitted From the Food Pattern: Some of the nutrients mentioned above are supplied in amounts well above the nutrient's goal level. However, there are some nutrient shortfalls if enriched grains are not included in the pattern (while keeping the whole grains recommendations as proposed).

   The food subgroups that would provide the most similar mix of nutrients to make up these shortfalls are additional whole grains, legumes, and dark green vegetables. For these groups, recommendations in the food pattern are already much higher than reported consumption (see Table G2-9). Further increases in the recommendations for these food subgroups would move the food pattern even farther away from what Americans now eat. Potential substitution of these foods for enriched grains in the pattern is discussed further in item 3 below.

   The specific shortfalls due to removal of enriched grains from the pattern (keeping whole grains), without replacement from other food groups, are listed below. Resulting amounts that are < 95 percent of the nutritional goal are included.

Nutrient	Food Pattern	Age-Sex Group (sedentary)	Existing Proposed Pattern—Amount in Pattern as % of Nutritional Goal	Without Enriched Grains—Amount in Pattern as % of Nutritional Goal
Folate	1600 (3m)	F 51+	103%	79%
	1800 (2m)	F31-50	117%	89%
	1800 (3m)	F14-18	120%	92%
Calcium	1600 (3m)	F 9-13	93%	87%
	1800 (2m)	F31-50	97%	88%
	1800 (3m)	M 9-13, F 14-18	98%	91%
	2000 (2m)	F19-30	101%	91%
	2200 (2m)	M 31-50	104%	92%
	2200 (3m)	M14-18	103%	94%
Magnesium	2000 (3m)	M 51+	97%	90%
	2200 (2m)	M31-50	95%	87%
Iron	1000 (2m)	M/F 2-3	103%	78%
	1200 (2m)	F 4-8	100%	76%
	1400 (2m)	M 4-8	121%	91%
	1800 (2m)	F31-50	97%	74%
	1800 (3m)	F 14-18	117%	90%
	2000 (2m)	F19-30	108%	82%
Fiber	1000 (2m)	M/F 2-3	88%	81%
	1200 (2m)	F 4-8	100%	91%
	1400 (2m)	M 4-8	100%	91%
	2200 (2m)	M31-50	102%	93%
	2200 (3m)	M 14-18	102%	93%

3. **Options for Modifying the Pattern To Make Up for Shortfalls if Enriched Grains Are Omitted**:

   a. *Increase amounts of added sugars and fats.* This recommendation would make up for the loss of calories but not make up for any of the shortfall nutrients, with the exception of vitamin E. Increased oils in the patterns would increase the amount of vitamin E in diets, but even if all of the approximately 300 calories from enriched grains were substituted with an additional 35 grams of oil, the vitamin E in the 1,800-calorie pattern, for example, would be only 80 percent of the RDA. (Note that this change brings fat calories to 45 percent of total calories.)

   b. *Increase amounts of dark green vegetables and/or legumes in the pattern.* Dark green vegetables provide more folate, calcium, magnesium, and fiber per serving than enriched grains. However, they provide slightly less iron per serving (1.04 vs. 1.17 mg per serving). Legumes provide more of all the shortfall nutrients per serving but also have more calories per serving (107 vs. 83). A daily recommendation of more than 1 cup *each* of legumes and dark green vegetables would be needed in the 1,800-calorie pattern to make up for the shortfalls if no enriched grains were included in the food pattern.

   c. *Increase amounts of whole grains in the pattern.* The nutrient profiles of the whole grain and enriched grain subgroups are very similar for many of the nutrients of interest. For example, a serving of whole grain provides 84 percent of the folate in enriched grains, 96 percent of the calcium, 139 percent of the iron, and 94 percent of the calories in enriched grains. The amounts of magnesium (380 percent) and fiber (323 percent) are greater in whole grains than enriched. The nutritional integrity of the food pattern would be maintained if all whole grains were substituted for the enriched grains in the proposed pattern. Some practical concerns arise, however, if

this approach is taken. For example, many of the grain products that Americans now select are a mix of whole and enriched grains. This issue is elaborated on below.

4. **Separation of Whole Grains From Enriched Grains Within Foods:** The process of assigning food group and subgroup servings to individual foods "decomposes" mixed foods into their various parts. This approach helps to accurately assign servings from each food group and subgroup to the many mixed dishes that are eaten. Food items that contain grains are assigned to *either or both* the whole grain and enriched grain subgroups. This means that the many grain products made of both whole and enriched grains—including many breads and ready-to-eat cereals—are calculated as part whole and part enriched grain.

   In practice, when a person selects a mixed grain bread or cereal, he gets *both* a whole grain portion and an enriched grain portion. Because of the desirable baking properties of enriched flour, these mixed grain products are often appealing to consumers who do not choose to eat 100 percent whole grains. For example, the most commonly eaten foods containing "whole grains" and the whole grains and enriched grain servings contained in 100 g of the food are listed below. These food items make up about 70 percent of all the whole grains consumed by Americans according to the CSFII 1994–1996 food consumption survey.

   These sample choices demonstrate the types of foods that consumers most often select that include at least some whole grains. While many are not entirely whole grains, they provide some whole grains in the diets of those who might not otherwise select any. The proposed Pyramid food pattern suggests that half of all grain servings be whole grains. This approach allows these mixed products to fit readily into a person's food choices.

Food (in order of the number of individuals reporting it in the CSFII 1994–1996 survey)	**Approx. Whole Grain Servings per 100 g***	**Approx. Enriched Grain Servings per 100 g***
100% whole wheat bread	3.4	0.1
Tortilla chips and corn chips	4.8	0.0
Popcorn	4.0	0.0
Pancakes	0.3	2.2
Oatmeal	0.8	0.0
Wheat bread/cracked wheat bread	1.3	2.7
Whole wheat bread (not 100%)	1.2	2.6
Multigrain/mixed grain breads	2.2	1.6
Rye and pumpernickel breads	1.4	2.4
Cheerios	3.3	0.1
Oatmeal cookies	0.9	0.3
Raisin bran cereal	1.8	0.8
Graham crackers	0.9	3.5
Granola bars	2.9	0.0
Bagels—not 100% whole wheat	0.9	2.6
Wheat crackers	2.5	2.6
Wheat/cracked wheat rolls	1.2	2.3

*Note: Whole and enriched grain servings per 100 grams are from the ARS Pyramid Servings Database that was developed for and is used in analysis of national food consumption surveys.

Recommendations

The Pyramid food pattern is designed to meet nutritional goals with the minimum necessary change from typical American food choices. All nutritional goals (with the exception of vitamin E) can be met with the amounts of enriched grains in the proposed pattern, which is approximately 40 to 75 percent of average enriched grain consumption. Replacement of the enriched grains in the food pattern with whole grains does not compromise the nutritional integrity of the pattern. However, it does violate the premise that changes from typical consumption patterns will be made only if needed to meet nutritional goals and makes the Pyramid less practical for many to follow, given the popularity of many mixed grain food products.

Some consumers, though, may not want to consume as many enriched grains as are included in the food pattern. We want to provide flexibility of choice where possible. A sensible approach to increase choice within grains might be to state that "at least half of the total amount of grains selected should be whole grains." This statement would allow consumers to select only whole grains if they wished and still follow the Pyramid food pattern. In educational materials, examples of food products that are whole grains, mixed whole and enriched grains, and enriched grains could help clarify how consumers can follow the Pyramid while selecting foods of their choice.

Table G2-7. Amount of Food From Each Group Recommended in the Proposed USDA Food Intake Pattern (in standard size "servings," or other units as noted)

Calorie Level & Age Groups	**1000** Child 2-3	**1200** F 4-8	**1400** M 4-8	**1600** F 9-13 F 51+	**1800** F 31-50 M 9-13 F 14-18	**2000** F 19-30 M 51+	**2200** M 31-50 M 14-18	**2400** M 19-30	**2600** M 19-30	**2800** M 14-18	**3000** M 19-30	**3200** M 14-18
Food Groups												
Fruits	1.5	1.5	2	2	2	3	3	3	4	4	5	5
Vegetables	1	2	2	3	4	4	4	5	6	6	7	7
Dark green	0.29	0.43	0.43	0.57	0.86	0.86	0.86	1	1	1	1.14	1.14
Deep yellow	0.14	0.29	0.29	0.43	0.57	0.57	0.57	0.71	0.86	0.86	1	1
Legumes	0.29	0.43	0.43	0.71	0.86	0.86	0.86	1	1	1	1.14	1.14
Starchy	0.14	0.43	0.43	0.57	0.71	0.71	0.71	1	1.29	1.29	1.29	1.29
Other	0.14	0.43	0.43	0.71	1	1	1	1.29	1.86	1.86	2.43	2.43
Grains	3	4	5	6	7	8	9	10	10	11	11	11
Whole grains	1.5	2	2.5	3	3.5	4	4.5	5	5	5.5	5.5	5.5
Enriched grains	1.5	2	2.5	3	3.5	4	4.5	5	5	5.5	5.5	5.5
Meat and Beans (in ounce eq.)	2	3	4	5	5	5.5	6	6.5	6.5	7	7	7
Milk (2 serv pattern)	2	2	2	2	2	2	2	2	2	2	2	2
(3 serv pattern)				3	3	3	3	3	3	3	3	3
Disc Fats (in g)	28	30	30	33	36	40	44	46	50	56	66	76
Solid fats	17	12	12	13	14	16	18	19	20	22	26	30
Oils/soft marg.	11	18	18	29	22	24	26	27	30	34	40	46
Added Sugars (in tsp.)	5	5	5	6	8	10	12	14	16	18	20	28
TOTAL CALORIES	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200

Table G2-8. Average Amounts Consumed From Each Food Group (CSFII 1994–1996, mean intake for each age/sex group, in "servings" or other units as noted)

Calorie Level	1000	1200	1400	1600	1600	1800	1800	1800	2000	2000	2200	2200	2400	2600	2800	3000	3200
Age Group	Child 2-3	F 4-8	M 4-8	F 9-13	F 51+	F 31-50	M 9-13	F 14-18	F 19-30	M 51+	M 14-18	M 31-50	M 19-30	M 19-30	M 14-18	M 19-30	M 14-18
Fruits	1.25	1.51	1.72	1.45	1.70	1.32	1.38	1.20	1.19	1.80	1.31	1.38	1.22	1.22	1.31	1.22	1.31
Vegetables	1.61	1.87	1.93	2.40	3.00	3.10	2.80	2.71	3.01	3.79	3.81	4.19	4.37	4.37	3.81	4.37	3.81
Dark green	0.07	0.07	0.05	0.07	0.21	0.20	0.08	0.08	0.14	0.21	0.10	0.17	0.11	0.11	0.10	0.11	0.10
Deep yellow	0.08	0.09	0.09	0.10	0.20	0.17	0.11	0.10	0.15	0.22	0.10	0.18	0.14	0.14	0.10	0.14	0.10
Legumes	0.09	0.10	0.10	0.12	0.15	0.16	0.19	0.16	0.17	0.26	0.22	0.29	0.29	0.29	0.22	0.29	0.22
Starchy	0.82	0.96	1.00	1.22	0.94	1.05	1.40	1.28	1.21	1.35	2.00	1.64	1.99	1.99	2.00	1.99	2.00
Other	0.55	0.65	0.70	0.88	1.51	1.52	1.03	1.09	1.36	1.76	1.39	1.90	1.85	1.85	1.39	1.85	1.39
Grains	4.50	5.40	5.99	6.33	5.02	5.57	7.56	6.17	5.97	6.62	9.44	7.94	8.70	8.70	9.44	8.70	9.44
Whole grains	0.69	0.79	0.89	0.93	0.90	0.80	1.12	0.81	0.79	1.11	1.15	1.07	1.01	1.01	1.15	1.01	1.15
Enriched grains	3.79	4.71	5.29	5.42	4.15	4.89	6.51	5.46	5.09	5.59	8.33	7.17	7.66	7.66	8.33	7.66	8.33
Meat and Beans (in ounce equiv.)	2.52	2.87	3.25	3.31	3.76	4.07	4.33	3.80	3.90	5.48	5.91	6.71	6.80	6.80	5.91	6.80	5.91
Milk (2 serv pattern)	1.85	1.84	2.02			1.11			1.26			1.55	1.73	1.73		1.73	
(3 serv pattern)				1.86	1.01		2.27	1.38		1.32	2.34				2.34		2.34
Disc Fats (in g)	40	46	50	52	40	48	63	51	49	57	79	74	75	75	79	75	79
Solid fats	23	27	29	30	23	28	36	30	28	33	46	43	43	43	46	43	46
Oils/soft marg.	17	19	21	22	17	20	26	22	21	24	33	31	31	31	33	31	33
Add. Sugars (in tsp.)	13	18	20	23	12	16	26	24	20	16	36	24	28	28	36	28	36
TOTAL CALORIES	1406	1604	1771	1836	1465	1665	2200	1835	1754	2035	2781	2538	2683	2683	2781	2683	2781

Table G2-9. Recommended Intakes in the Proposed USDA Food Pattern Compared to Actual Mean Consumption (recommended as a percent of actual, by age/sex group)

Calorie Level	**1000**	**1200**	**1400**	**1600**	**1600**	**1800**	**1800**	**1800**	**2000**	**2000**	**2200**	**2200**	**2400**	**2600**	**2800**	**3000**	**3200**
Age Groups	Child 2-3 (%)	F 4-8 (%)	M 4-8 (%)	F 9-13 (%)	F 51+ (%)	F 31-50 (%)	M 9-13 (%)	F 14-18 (%)	F 19-30 (%)	M 51+ (%)	M 14-18 (%)	M 31-50 (%)	M 19-30 (%)	M 19-30 (%)	M 14-18 (%)	M 19-30 (%)	M 14-18 (%)
Fruits	120	99	116	138	117	151	145	166	253	166	229	217	246	327	305	409	382
Vegetables	62	107	103	125	100	129	143	148	133	106	105	96	114	137	158	160	184
Dark green	434	642	925	799	277	431	1097	1060	633	419	898	501	896	896	1045	1021	1191
Deep yellow	174	314	326	416	213	327	541	585	388	254	547	308	520	629	826	732	960
Legumes	319	435	437	598	468	542	447	548	515	336	394	299	346	346	458	394	522
Starchy	17	45	43	47	61	68	51	55	59	53	35	43	50	65	64	65	64
Other	25	66	62	80	47	66	97	92	74	57	72	53	70	101	134	132	175
Grains	67	74	83	95	120	126	93	114	134	121	95	113	115	115	117	126	117
Whole grains	217	254	279	322	334	437	313	434	504	359	393	419	495	495	480	544	480
Enriched grains	40	42	47	55	72	72	54	64	79	72	54	63	65	65	66	72	66
Meat and Beans	79	104	123	151	133	123	115	132	141	100	102	89	96	96	118	103	118
Milk (2 serv pattern)	108	108	99			180			159			129	116	116		116	
(3 serv pattern)				162	296		132	217		228	128				128		128
Disc Fats (in g)	70	65	60	64	82	76	57	70	82	70	56	60	61	67	71	88	96
Solid fats	73	45	41	43	56	51	39	47	56	48	39	42	44	46	48	60	65
Oils/soft marg.	65	93	85	92	119	110	84	102	117	99	78	84	86	95	102	127	138
Added Sugars	38	28	26	26	50	50	31	33	49	62	33	50	50	58	50	72	77
TOTAL CALORIES	71	75	79	87	109	108	82	98	114	98	79	87	89	97	101	112	115

Alternatives for Legumes In the Food Intake Pattern Analysis—April 5, 2004

Request From the Nutrient Adequacy Subcommittee

Is it possible to offer more flexibility in the food pattern for those who do not want to consume legumes by identifying alternative foods that will make up for nutrient shortfalls in the proposed pattern with no legumes?

Background

Legumes provide a broad array of vitamins, minerals, and macronutrients. The most commonly consumed legumes are pinto beans, white beans, kidney beans, tofu, black beans, lentils, chickpeas, cowpeas, split peas, and lima beans. Because of their rich mix of nutrients, the amounts of legumes recommended in the proposed food intake pattern were increased above current consumption. However, recommended intakes are still fairly small in relation to other food groups. Therefore, for any given nutrient, the percent of total intake provided by legumes is modest. Table G2-10 provides information on current consumption levels and proposed recommendations for legume intake as background for this analysis.

Table G2-10. Total Vegetable and Legume Food Intake Pattern Recommendations in Comparison to Reported Consumption

		All Vegetables		Legumes			
Food Pattern in Calories	**Age/Sex Groups**	**Recom-mendation** (# ½ cup servings)	**Reported Consumption** (# ½ cup servings)	**Recom-mendation** (# ½ cup servings)	**Reported Consumption** (# ½ cup servings)	**Recommended Increase Over Current Consumption** (# ½ cup servings)	(Percent)
1000	Child 2-3	1	1.61	0.29	0.09	0.20	319
1200	F 4-8	2	1.87	0.43	0.10	0.33	435
1400	M 4-8	2	1.93	0.43	0.10	0.33	437
1600	F 9-13	3	2.40	0.71	0.12	0.59	598
	F 51+	3	3.00	0.71	0.15	0.56	468
1800	F 31-50	4	3.10	0.86	0.16	0.70	542
	M 9-13	4	2.80	0.86	0.19	0.67	447
	F 14-18	4	2.71	0.86	0.16	0.70	548
2000	F 19-30	4	3.01	0.86	0.17	0.69	515
	M 51+	4	3.79	0.86	0.26	0.60	336
2200	M 14-18	4	3.81	0.86	0.22	0.64	394
	M 31-50	4	4.19	0.86	0.29	0.57	299
2400	M 19-30	5	4.37	1.00	0.29	0.71	346
2600	M 19-30	6	4.37	1.00	0.29	0.71	346
2800	M 14-18	6	3.81	1.00	0.22	0.78	458
3000	M 19-30	7	4.37	1.14	0.29	0.85	394
3200	M 14-18	7	3.81	1.14	0.22	0.92	522

Note that the recommended increase in legume intake is large when expressed as a percentage of current consumption but modest in actual amount. For adults, the increase ranges from about ¼ cup (0.56 servings) to less than ½ cup (0.92 servings) per day.

Methods

1. Used the proposed food intake pattern and nutrient profiles based on 1999–2000 NHANES consumption data and the SR 16 nutrient data as the basis for this analysis.
2. Identified nutrients provided by legumes.
3. Removed legumes from each food pattern and analyzed the adequacy of the resulting food pattern. Identified nutrient shortfalls.
4. Determined which other food groups would best compensate for these shortfalls within goal levels for calories.
5. Increased amounts of the identified food groups in each pattern and analyzed the adequacy of the resulting food pattern.

Results

1. **Nutrients Provided by Recommended Amounts of Legumes in the Food Pattern:** On average, legumes provide 4.3 percent of the calories in the food intake pattern. They also provide more than 5 percent of the following nutrients in the pattern (on average): vitamin E, folate, phosphorus, magnesium, iron, zinc, copper, potassium, protein, carbohydrate, fiber, and α-linolenic acid. Since some of these nutrients are provided by the food pattern in amounts far exceeding the RDA or AI, the nutrient contribution of legumes was also compared to specific nutrient standards. For example, in the 1,800-calorie food pattern (with two milk servings), the contribution of legumes to the recommended intake of each nutrient is shown in Table G2-11.

Table G2-11. Amounts of Nutrients in Legumes Recommended for Adult Females in Comparison to RDA for Each Nutrient

Nutrient		**Amount in 0.43 Cups* Legumes**	**DRI for Nutrient (female 31–50)**	**% of RDA or AI per 0.43 Cups of Legumes (female 31–50)**
Vitamin E	mg AT	0.50	15	3%
Thiamin	mg	0.09	1.10	9%
Riboflavin	mg	0.04	1.10	4%
Vitamin B_6	mg	0.07	1.30	6%
Folate	mcg	95	400	24%
Calcium	mg	48	1000	5%
Phosphorus	mg	99	700	14%
Magnesium	mg	37	320	12%
Iron	mg	2	18	11%
Zinc	mg	1	8	11%
Potassium	mg	276	4700	6%
Calories	kcal	97	1800	5%
Protein	g	7	46	15%
Carbohydrates	g	16	130	12%
Dietary fiber	g	5	25	20%
Linoleic acid	g	0.32	12	3%
α-linolenic acid	g	0.10	1.10	9%

*Note: 0.43 cups per day, or 3 cups per week, is the recommended amount of legumes in the proposed 1,800-calorie food intake pattern for sedentary adult women age 31 to 50 years.

2. **Impact of Removing Legumes From the Food Pattern:** Some of the nutrients provided by legumes are supplied in amounts well above the nutrient's goal level. However, there are some nutrient shortfalls if legumes are not included in the pattern. The specific shortfalls due to removal of legumes from the pattern, without replacement from other food groups, are listed in Table G2-12. Resulting amounts that are <95 percent of the nutritional goal are included.

Note: Vitamin E and potassium are not included in the table. Vitamin E levels are below the RDA for all patterns; without legumes the levels of vitamin E decreased an additional 3 to 4 percent of the RDA. Potassium levels in almost all patterns are also below the AI; without legumes, the levels of potassium in all patterns decreased an additional 5 to 6 percent of the AI.

Table G2-12. Nutrient Shortfalls Without Legumes in the Food Pattern

Nutrient	Food Pattern	Age-Sex Group (sedentary)	Existing Proposed Pattern—Amount in Pattern as % of Nutritional Goal	Without Legumes —Amount in Pattern as % of Nutritional Goal
Calcium	1600 (3m)	F 9-13	96%	93%
	1800 (2m)	F 31-50	101%	96%
	1800 (3m)	M 9-13, F 14-18	101%	97%
Magnesium	1600 (3m)	F 51+	100%	91%
	1800 (2m)	F 31-50	104%	92%
	1800 (3m)	F 14-18	100%	89%
	2000 (3m)	M 51+	94%	85%
	2200 (2m)	M 31-50	93%	87%
	2200 (3m)	M 14-18	101%	92%
	2400 (2m)	M 19-30	107%	97%
Iron	1000 (2m)	M/F 2-3	101%	92%
	1200 (2m)	F 4-8	98%	88%
	1800 (2m)	F31-50	96%	85%
	2000 (2m)	F19-30	107%	96%
Fiber	1000 (2m)	M/F 2-3	86%	74%
	1200 (2m)	F 4-8	97%	82%
	1400 (2m)	M 4-8	97%	84%
	1600 (3m)	F 9-13, F 51+	106%	88%
	1800 (2m)	F31-50	111%	92%
	1800 (3m)	F 14-18	111%	92%
	2000 (2m)	F19-30	112%	95%
	2000 (3m)	M 51+	112%	95%
	2200 (2m)	M31-50	109%	92%
	2200 (3m)	M 14-18	109%	92%
	2400 (2m)	M 19-30	112%	95%
	2600 (2m)	M 19-30	112%	97%
	2800 (3m)	M 14-18	110%	95%
	3000 (2m)	M 19-30	111%	96%
	3200 (3m)	M 14-18	105%	91%

The most widespread impact was on fiber, with decreases to less than the AI for almost all food intake patterns. Magnesium also decreases to less than the RDA for teens and adult men and women. Iron was less than the RDA for all premenopausal women and young children.

3. **Options for Modifying the Pattern To Make Up for Shortfalls if Legumes Are Omitted:** The nutrients of concern with no legumes in the pattern are dietary fiber, magnesium, iron, calcium, vitamin E, and potassium. Other food groups and subgroups that provide substantial amounts of these nutrients and nutrient content in an amount approximating the calories in ½ cup of legumes were identified. In addition to the nutrients of concern, folate is included in Table G2-13 because legumes provide such a high percentage of the overall folate in the food pattern.

Dark green vegetables, whole grains, and other vegetables appear to provide the closest match with the nutrients provided by legumes. Orange vegetables do not provide sufficient iron or magnesium; starchy vegetables do not provide sufficient fiber or magnesium; and fruits do not provide enough fiber, iron, or magnesium. Whole grains provide sufficient fiber and other nutrients but at a slightly higher calorie level. Therefore, the amount of enriched grains was adjusted downward to compensate.

The results of the food pattern analysis with the following substitutions for legumes follow.

Increased amounts of whole grains and decreased amounts of enriched grains. For each ½ cup of legumes in the food pattern, whole grains were increased by 2 ounces and enriched grains decreased by 0.5 ounce. Overall, recommended amounts of grains increased by about ½ to 1½ ounces. Shortfalls of magnesium, iron, and calcium were totally replaced. Shortfalls of fiber were almost completely eliminated, with the exception of young children, whose intake levels were slightly below those in the original pattern (83 percent for age 2 to 3 years and 93 percent for age 4 to 8 years). Amounts of potassium in all food patterns decreased by 3 to 4 percent of the RDA and of vitamin E by 2 to 3 percent of the RDA from amounts in the original proposed pattern. The resulting food intake pattern would recommend about fourfold to sixfold increases in the amounts of whole grains over what is now consumed.

Increased amounts of dark green vegetables. For each ½ cup of legumes in a food pattern, dark green vegetables were increased by 1½ cups. Daily amounts of all vegetables recommended increased by ¼ to 1 cup, and amounts of dark green vegetables recommended increased by about ¼ to 1½ cups per day. For example, the proposed 1,800-calorie pattern (for adult women age 31 to 50 years) recommended 2 cups of vegetables, of which ½ cup would be dark green vegetables. A revised pattern with no legumes would recommend almost 3 cups of vegetables a day, with more than 1½ cups of that as dark green vegetables. With these changes to the intake pattern, shortfalls of magnesium, iron, calcium, and dietary

Table G2-13. Comparison of Nutrients in Other Foods to Amounts in Legumes

Food Group	Amount	Calories	Fiber, g	Magnes., mg	Iron, mg	Calcium, mg	Folate, mg	Vit. E, mg AT	Potass., mg
Legumes	½ cup	113	5.79	43.08	2.25	55.76	111	0.58	321
Dk green veg.	1½ cups	60	6.17	74.29	2.88	150.38	244	3.02	687
Orange veg.	1½ cups	96	6.47	28.03	0.81	68.41	31	1.82	641
Starchy veg.	¾ cup	110	2.55	28.06	0.59	11.31	20	0.03	430
Other veg.	3 cups	104	6.24	59.54	3.29	128.53	104	2.22	979
Whole grains	2 oz.	155	4.49	53.77	3.17	57.94	74	0.19	157
(minus 0.5 oz. enriched grains)		-42	-0.36	-3.56	-0.62	-15.34	-18	-0.03	-14
Fruits	1 cup	139	2.67	29.11	0.59	25.41	57	0.43	506

fiber were totally replaced. Amounts of potassium in all food patterns increased by about 6 to 7 percent of the RDA and of vitamin E by about 14 to 18 percent of the RDA. However, the resulting food intake patterns would recommend about tenfold to fortyfold increases in the amounts of dark green vegetables over what is now consumed.

Increased amounts of other vegetables (tomatoes, lettuce, green beans, cabbage, onions, etc.) in the pattern. For each ½ cup of legumes in a food pattern, the amount of other vegetables was increased by 2 cups. Daily amounts of all vegetables recommended increased by ¾ to 2¾ cups; amounts of other vegetables recommended increased by about 1 to 3½ cups per day. For example, the 1,800-calorie pattern (for adult women age 31 to 50 years) originally recommended 2 cups of vegetables, of which ½ cup would be other vegetables. A revised pattern with no legumes would recommend more than 4 cups of vegetables a day, with more than 3 cups of that as other vegetables. With these changes to the intake pattern, shortfalls of magnesium, iron, calcium, and dietary fiber were totally replaced. Amounts of potassium in all food patterns increased by 10 to 14 percent of the RDA and of vitamin E by 9 to 11 percent of the RDA. The resulting food intake pattern would recommend about threefold to fivefold increases in the amounts of other vegetables over what is now consumed and a doubling to tripling of overall vegetable consumption.

Conclusion

The proposed food intake pattern meets all nutritional goals, with the exception of vitamin E and potassium. Flexibility in the pattern is suggested through choices made within food groups or subgroups. However, some individuals may not choose to eat any foods from a particular group. For these individuals, nutrient adequacy will not be met unless compensating changes are made in other food choices. To maintain energy balance, the alternative foods selected should not increase calorie intake.

For those who choose not to eat any legumes, several alternative approaches will meet nutrient needs. Individuals who do not consume legumes can be encouraged to increase whole grain consumption, while decreasing enriched grain consumption slightly to balance energy intake. However, vitamin E and potassium intake are slightly decreased with this approach. Alternatively, they can substantially increase their intake of other vegetables, such as tomatoes, lettuce, green beans, and cabbage. The latter approach requires intake of a large quantity of these vegetables, about 3 or more cups each day for many adults, and a total vegetable intake of 4 or more cups per day. The third option, to increase dark green vegetable consumption, does not seem realistic, as increases of tenfold to fortyfold in dark green vegetable consumption would be required.

Nutrient Contributions of Each Food Group

(Updated May 24, 2004, To Include Changes To Increase Potassium in Pattern)

Purpose

To determine the nutrient contributions of each food group and subgroup in the proposed food intake pattern.

Methods

1. For each nutrient, calculate the percentage of the total in each food pattern that is contributed by each food group and subgroup. For example, the 1,800-calorie pattern (with two milk servings) contains 106 mg of vitamin C, of which 60 mg (56 percent) comes from the fruit group, and 43 mg (41 percent) comes from the vegetable group.
2. Calculate the average percentage of contributions across the food pattern at all calorie levels.
3. For each food group, determine the nutrient(s) for which the food group is the major contributor and other nutrients for which the group provides substantial (>10 percent of total) contributions. This part of the analysis was completed for nutrients having adequacy goals only (not for moderation goals).

Results

- Each food group is the major contributor of at least one nutrient. In addition, each group provides substantial contributions for many other nutrients. Table G2-14 summarizes the nutrient contributions of each food group and subgroup.
- Subgroup contributions in the table are shown for the vegetable and grain groups. Note that the amount recommended to eat from each vegetable subgroup in a food pattern is small in comparison to the amounts recommended from other food groups. Therefore, for many nutrients, the contributions from each vegetable

subgroup are not greater than 10 percent of the total. However, the vegetable subgroups provide smaller amounts of a wide range of nutrients.

- For a few nutrients, the food group that is the major contributor of a nutrient shifts from pattern to pattern. For example, for potassium the milk group is the major contributor in most food patterns, but in the higher calorie pattern with more fruit servings, the fruit group is the major contributor of potassium.
- For a few nutrients, a single food group provides a majority of the overall amount in the food pattern. This is true for vitamin C, for which the fruit group provides about 67 percent of the total; calcium, for which the milk group provides about 67 percent; iron, for which the grains group contributes 53 percent; and linoleic and α-linolenic acids, for which oils and soft margarines provide about 59 percent and 53 percent, respectively. For all other nutrients, no single food group provides more than half of the total nutrient in the food pattern.
- Each food group provides a wide array of nutrients in substantial amounts.

Table G2-14. Summary of the Nutrient Contributions of Each Food Group (averaged over the food pattern at all energy levels)

Food Group	**Major Contribution(s)**	**Substantial Contribution(s) (>10% of total)**
Fruit group	Vitamin C	Thiamin Vitamin B_6 Folate Magnesium Copper Potassium Fiber Carbohydrates
Vegetable group	Vitamin A Vitamin B_6 (tie) Potassium Copper Fiber	Vitamin E Vitamin C Thiamin Niacin Vitamin B_6 Folate Calcium Potassium Phosphorus Magnesium Iron Zinc Copper Carbohydrate Protein Fiber α-linolenic acid
Vegetable subgroups		
–Dark green vegetables		Vitamin A Vitamin C
–Orange vegetables	Vitamin A	
–Legumes		Folate Copper Fiber
–Starchy vegetables		Vitamin B_6 Copper
–Other vegetables		Vitamin C

Food Group	Major Contribution(s)	Substantial Contribution(s) (>10% of total)
Grain group	Thiamin Folate Magnesium Iron Carbohydrate	Vitamin A Riboflavin Niacin Vitamin B_6 Vitamin B_{12} Calcium Phosphorus Copper Zinc Protein Fiber Linoleic acid α-linolenic acid
Grain subgroups –Whole grains	Folate (tie) Magnesium Iron Carbohydrate (tie)	Thiamin Riboflavin Niacin Vitamin B_6 Vitamin B_{12} Phosphorus Copper Zinc Fiber
–Enriched grains	Thiamin Folate (tie) Carbohydrate (tie)	Folate Riboflavin Niacin Iron Copper
Meat, poultry, fish, eggs, and nuts group	Niacin Vitamin B_6 (tie) Zinc Protein	Vitamin E Thiamin Riboflavin Vitamin B_{12} Phosphorus Magnesium Iron Copper Potassium Linoleic acid
Milk group	Riboflavin Vitamin B_{12} Calcium Phosphorus	Vitamin A Thiamin Vitamin B_6 Magnesium Zinc Potassium Carbohydrate Protein
Oils and soft margarines	Vitamin E Linoleic acid α-linolenic acid	

Fruit and Fruit Juice Analysis—April 8, 2004

Request From the Nutrient Adequacy Subcommittee

What is the impact of removing fruit juice from the food pattern?

Methods

Note: All items considered "fruit juice" in this analysis are 100 percent fruit juice. Fruit drinks and "ades" are not included.

1. Used the proposed food intake pattern and nutrient profiles based on 1999–2000 NHANES consumption data and the SR 16 nutrient data as the basis for this analysis.
2. Separated all item groups that comprise the fruit nutrient profile into four categories and created separate nutrient profiles for each:
   a. Citrus fruit, melons, and berries
   b. Citrus juices (orange and grapefruit)
   c. Other fruits (bananas, apples, grapes, peaches, pears, etc.)
   d. Other juices (apple and grape)
3. Created a nutrient profile for fruits only, eliminating all juices (b and d).
4. Analyzed the adequacy of the resulting food pattern first with the amounts of fruits held constant, then adjusted the amounts of fruits to compensate for the amount of juices removed. Citrus, melons, and berries were increased to compensate for citrus juices, and other fruits were increased to compensate for other juices.

Results

1. Fruit intakes across all ages (2 years and older), based on NHANES 1999–2000 consumption data, were approximately
   22 percent citrus fruit, melons, and berries
   25 percent citrus juices (orange and grapefruit)
   41 percent other fruits (bananas, apples, grapes, peaches, pears, etc.)
   12 percent other juices (apple and grape)

Total fruit juice intake was about 37 percent of all fruit intake, across all ages, with the majority of the juice intake as citrus juice. While not assessed separately in this analysis, previous analysis (CSFII 1989–1991) has shown that young children's intakes of fruit and fruit juice were approximately 47 percent juice (23 percent citrus and 24 percent other) and 53 percent fruits.

2. The nutrient profile for the fruit group was altered by removing juices and substituting their portion of the composite with fruits. Nutrients that had the greatest changes are shown in Table G2-15.

Table G2-15. Changes in the Nutrient Profile of the Fruit Group With All Juices Replaced With Fruits (Selected Nutrients) (all values per one serving from the fruit group composite)

Nutrient	Original Nutrient Profile (fruit plus juice)	Modified Nutrient Profile With Fruit Replacing Juices	Percentage Change
Vitamin A (mcg RAE)	18.7	33.38	+78.2%
Vitamin C (mg)	29.76	21.88	-26.5%
Folate (mcg)	28.30	14.02	-50.5%
Thiamin (mg)	0.066	0.040	-39.6%
Magnesium (mg)	14.559	13.289	-8.7%
Potassium (mg)	252.93	210.87	-16.6%
Calories	69.75	54.77	-21.5%
Fiber (g)	1.339	1.828	+36.6%
α-linolenic acid (mg)	0.015	0.022	+43.5%

3. The impacts on overall dietary patterns of removing the juices and then replacing the juices with fruit are detailed below.
   - **Vitamin C:** Removing the juices without replacement resulted in substantial decreases in vitamin C in all food patterns. Since vitamin C is well above the RDA level, the decrease created shortfalls for vitamin C only for some age/sex groups, which are shown in Table G2-16. Replacing the juice with fruit corrected all of the shortfalls.
   - **Potassium:** The removal of juices exacerbated the shortfalls in potassium in all patterns. Amounts in each pattern were decreased about 5 percent of the RDA, and all patterns, except 3,200 calories, decreased to less than 100 percent of the RDA. With fruit replacing juice, in comparison to fruit and juice, potassium levels were about 2 percent of the RDA less. For example, for females age 31 to 50 years, the original 1,800-calorie food pattern contained 66 percent of the RDA for potassium. Without fruit juice, the pattern contained 61 percent of the RDA, and with fruit replacing juice, 64 percent of the RDA.
   - **Magnesium:** The removal of juices resulted in shortfalls in magnesium for some age/sex groups, as shown in Table G2-17. Magnesium intake was already marginal for some adult men.
   - **Fiber:** Fiber intake was not substantially affected by removing fruit juices from the patterns, as shown in Table G2-18. Intakes were somewhat improved by replacing juices with fruits for children age 8 and younger whose fiber intakes in the original pattern were marginal.

Table G2-16. Amounts of Vitamin C in the Food Pattern With Fruit Intake Modified

Age/Sex Group (food pattern)	**Vitamin C in Original Food Pattern (% RDA)**	**Vitamin C in Pattern Without Fruit Juice (% RDA)**	**Vitamin C in Pattern With Fruit Replacing Juice (% RDA)**
Females 51–70 (1600 calories)	123%	74%	102%
Females 31–50 (1800 calories)	141%	92%	120%
Males 51–70 (2000 calories)	151%	89%	125%
Males 31–50 (2200 calories)	151%	90%	125%

Table G2-17. Amounts of Magnesium in the Food Pattern With Fruit Intake Modified

Age/Sex Group (food pattern)	**Magnesium in Original Pattern (% RDA)**	**Magnesium in Pattern Without Fruit Juice (% RDA)**	**Magnesium in Pattern With Fruit Replacing Juice (%RDA)**
Females 51-70 (1600 calories)	100%	97%	100%
Females 14-18 (1600 calories)	100%	96%	99%
Males 51-70 (2000 calories)	94%	90%	93%
Males 31-50 (2200 calories)	93%	88%	92%
Males 14-18 (2200 calories)	101%	97%	100%

Table G2-18. Amounts of Fiber in Food Patterns With Fruit Intake Modified

Age/Sex Group (food pattern)	Fiber in Original Pattern (% AI)	Fiber in Pattern Without Fruit Juice (% AI)	Fiber in Pattern With Fruit Replacing Juice (% AI)
Children 1-3 (1000 calories)	86%	85%	91%
Females 4-8 (1200 calories)	97%	96%	101%
Males 4-8 (1400 calories)	97%	96%	102%

Conclusions

Fruit juices provide substantial contributions of several vitamins and minerals in higher amounts than do whole fruits. These include vitamin C, folate, and potassium. However, replacement of fruit juice with fruit does not result in shortfalls, with the exception of nutrients that are already in shortfall amounts in the food intake pattern.

Some types of fruit have more potassium than others. Since potassium is low in almost all food patterns, suggestions for selecting at least some fruit or juice rich in potassium could help to increase overall intakes. Of the subcategories created for this analysis of juice and fruit intake, citrus juices have the highest level of potassium. A table of rich sources of potassium is being prepared and could be included in the report.

The current analysis assumes that intake from the fruit group is approximately 1/3 juice and 2/3 fruit when averaged across all age groups. Previous analysis suggests that young children may, in fact, consume relatively more juice and less fruit. They also may consume relatively more apple and grape juice, and less citrus juice than other age groups. For children who consume mostly juice and little fruit, shortfalls in fiber would be increased. For children age 8 and younger, replacing some juice with fruit could help meet the fiber recommendations. Recommending intake of no more than 1/3 juice and no less than 2/3 fruit would promote adequate fiber intakes.

A recommendation to select at least 2/3 fruits and no more than 1/3 juice is consistent with current overall consumption. This recommendation for total juice intake is also consistent with the recommendation from the American Academy of Pediatrics to limit fruit juice to no more than 4 to 6 ounces per day for children age 1 to 6 years and 8 to 12 ounces per day for children age 7 to 18 years.

Milk Products—Nutrient Contributions—April 9, 2004

Request From the Nutrient Adequacy Subcommittee

What are the nutrient shortfalls in the food intake pattern if milk and milk products are not consumed?

Background

Milk and milk products provide more than 70 percent of the calcium consumed by Americans, based on food supply data. This contribution has remained relatively constant over time, with a gradual decrease from about 75 percent in the early 1970s to about 72 percent in 2000. (Note that the percent contributions of calcium by food groups from NHANES 1999–2000 is not yet available.) Foods included in the milk group include all fluid milks, cheeses, yogurt, and other dairy products such as puddings, flavored milks, milk shakes, milk-based meal replacements, and frozen desserts. Items excluded are those that are primarily fat (butter, cream, sour cream, and cream cheese).

Because they provide so much of the overall calcium in American diets, milk products have been traditionally identified as a separate food group to highlight their importance for meeting calcium needs. This analysis identifies calcium and other nutrients for which milk products make a substantial contribution and nutrient shortfalls if milk products are not consumed. Reported intakes from the milk group, intake recommendations, and the percentage of calcium provided by this food group in the proposed food pattern are presented in Table G2-19.

Table G2-19. Milk Group Intake Recommendations in Comparison to Reported Consumption and Percentage Contribution of Milk Group to Calcium Intake

Food Pattern (calories)	**Age/Sex Groups**	**Milk Group Recommendation** (1 cup eq. servings)	**Reported Consumption (CSFII 1994-1996)** (1 cup eq. servings)	**Calcium Provided by Milk Group in Food Patterns** (% of total calcium)
1000	Child 2-3	2	1.85	79
1200	F 4-8	2	1.84	73
1400	M 4-8	2	2.02	70
1600	F 9-13	3	1.86	73
	F 51+	3	1.01	73
1800	F 31-50	2	1.11	61
	M 9-13	3	2.27	70
	F 14-18	3	1.38	70
2000	F 19-30	2	1.26	58
	M 51+	3	1.32	68
2200	M 14-18	3	2.34	66
	M 31-50	2	1.55	56
2400	M 19-30	2	1.73	53
2600	M 19-30	2	1.73	52
2800	M 14-18	3	2.34	61
3000	M 19-30	2	1.73	49
3200	M 14-18	3	2.34	59

Methods

1. Used the proposed food intake pattern and nutrient profiles based on 1999–2000 NHANES consumption data and the SR 16 nutrient data as the basis for this analysis.
2. Identified nutrients provided by the milk group.
3. Removed milk group from each food pattern and analyzed the adequacy of the resulting pattern. Identified nutrient shortfalls.

Results

1. **Nutrients Provided by Recommended Amounts From the Milk Group in the Food Pattern:** On average, the milk group provides 10 percent of the calories in the food intake pattern. The percentage varies from 16 percent of calories at 1,000 calories to 5 percent at 3,200 calories, because the intake amounts recommended from the milk group do not increase with increasing calorie intakes. The milk group also provides more than 10 percent of the following nutrients in the pattern (on average): riboflavin, vitamin B_{12}, vitamin A, thiamin, vitamin B_6, calcium, phosphorus, magnesium, zinc, potassium, protein, and carbohydrate.

2. **Impact of Removing Milk Products From the Food Pattern:** Some of the nutrients provided by milk products are supplied in amounts well above the nutrient's goal level. For example, even though milk products are the major contributor of riboflavin to the food pattern, intake levels are still above the RDA when milk products are excluded. Amounts of riboflavin drop from about 200 to 250 percent of the RDA to about 111 to 170 percent of the RDA. However, there are some other nutrient shortfalls, in addition to calcium, if milk products are not included in the pattern.

   The specific shortfalls due to the removal of milk products from the pattern, without replacement from other food groups, are listed in Table G2-20. Nutrients are included if the resulting amount is <95 percent of the nutritional goal. Note that vitamin E is not included in the table. Vitamin E levels are below the RDA for all patterns, and without milk products, the levels of vitamin E in the pattern decrease by 1 percent or less of the RDA.

Table G2-20. Nutrient Shortfalls Without Milk Products in the Food Pattern

Nutrient	Food Pattern	Age-Sex Group (sedentary)	Existing Proposed Pattern—Amount in Pattern as % of Nutritional Goal	Without Milk Products—Amounts in Pattern as % of Nutritional Goal
Calcium	1000 (2m)	M/F 2-3	155%	32%
	1200 (2m)	F 4-8	104%	28%
	1400 (2m)	M 4-8	110%	33%
	1600 (3m)	F 9-13	96%	26%
	1600 (3m)	F 51 tó 70	104%	28%
	1800 (2m)	F 31-50	101%	40%
	1800 (3m)	M 9-13, F 14-18	101%	30%
	2000 (2m)	F 19-30	105%	44%
	2000 (3m)	M 51+	113%	37%
	2200 (2m)	M 31-50	109%	48%
	2200 (3m)	M 14-18	107%	37%
	2400 (2m)	M 19-30	115%	53%
	2600 (2m)	M 19-30	118%	57%
	2800 (3m)	M 14-18	117%	46%
	3000 (2m)	M 19-30	125%	64%
	3200 (3m)	M 14-18	120%	49%
Potassium	1000 (2m)	M/F 2-3	58%	33%
	1200 (2m)	F 4-8	56%	36%
	1400 (2m)	M 4-8	64%	43%
	1600 (3m)	F 9-13	71%	45%
	1600 (3m)	F 51+	68%	43%
	1800 (2m)	F 31-50	66%	49%
	1800 (3m)	M 9-13	77%	52%
	1800 (3m)	F 14-18	74%	49%
	2000 (2m)	F 19-30	73%	57%
	2000 (3m)	M 51+	81%	57%
	2200 (2m)	M 31-50	75%	59%
	2200 (3m)	M 14-18	84%	59%
	2400 (2m)	M 19-30	83%	66%
	2600 (2m)	M 19-30	92%	76%
	2800 (3m)	M 14-18	103%	78%
	3000 (2m)	M 19-30	104%	88%
	3200 (3m)	M 14-18	112%	88%
Magnesium	1600 (3m)	F 51 to 70	100%	75%
	1800 (2m)	F 31-50	104%	87%
	1800 (3m)	F 14-18	100%	77%
	2000 (3m)	M 51+	94%	75%
	2200 (2m)	M 31-50	93%	80%
	2200 (3m)	M 14-18	101%	82%
	2400 (2m)	M 19-30	107%	94%
Phosphorus	1000 (2m)	M/F 2-3	193%	85%
	1600 (3m)	F 9-13	128%	69%
	1800 (3m)	M 9-13, F 14-18	137%	77%
	2200 (3m)	M 14-18	153%	93%
Vitamin A	1600 (3m)	F 51-70	122%	92%

The most widespread impacts were on calcium and potassium, with decreases to less than the AI for almost all food intake patterns. Intakes of magnesium, phosphorus, and vitamin A also were affected. Magnesium levels were low for all teen and adult men, and for many teen and adult women. Phosphorus levels were low for teen and preteen males and females, and for children age 2 to 3 years. Vitamin A levels were low for women age 50 and older.

The DRI report for phosphorus notes that phosphorus is widely used as an additive in processed foods, and assessment of intakes may be difficult to ascertain, but intake data suggest an increase in consumption in the range of 10 to 15 percent over the past 20 years. Therefore, the issue of phosphorus intake is not further considered in this report.

3. **Options for Alternatives to Milk Products in the Food Pattern:** Alternatives within the milk group may be the most feasible recommendations for many individuals who avoid milk because of its lactose content. The same mix of nutrients found in regular milk products is also in lactose-reduced or low-lactose milk products.

   For those who do not wish to consume any dairy products, several considerations are important. First, the alternative must have high calcium and potassium levels. Second, the calcium must be in a form that is bioavailable. Also, consideration should be given to sources of magnesium and perhaps vitamin A.

   A table of potential alternatives for milk products is being prepared. No scenarios for replacement of milk products with other foods were developed because this would necessitate enormous deviations from typical food choices. In addition, the most viable alternatives for many individuals may be alternative foods within the milk group or fortified foods such as fortified orange juice or fortified soy products.

Conclusion

Calcium and potassium intakes are severely compromised if milk products are not included in the food pattern. Calcium is already marginal for some age/sex groups in the pattern, and reported intakes for most groups are below recommendations. Potassium intakes in the population and in the proposed pattern are below new recommendations, as well.

While milk products are clearly, and correctly, associated with calcium, no food group, including the milk group, provides only a single nutrient. Any recommendations to increase flexibility in the food pattern by suggesting alternatives to milk products need to consider the impacts on the intake of potassium, magnesium, and vitamin A.

Report on Varying Levels of Fats in the Food Pattern—February 25, 2004

Request From the Fatty Acids Subcommittee

Examine the adequacy of the food pattern with varying levels of fat, from 20 to 35 percent of calories.

Rationale for Request

To determine if the food pattern at varying levels of fat content within the range recommended by the DRI can meet adequacy and moderation goals for other nutrients.

Context for the Analysis

1. **Total vs. Foundation Diet Approach:** The Food Guide Pyramid is a total diet system, which means that all calories must be accounted for in some way. This diet system differs fundamentally from a foundation diet, which ensures nutrient adequacy but allows free choice of any additional calories to meet energy needs. The free choice of some calories in a foundation diet approach is not compatible with moderation goals, such as limiting saturated fat intake. The total diet approach is used because some of the nutritional goals for the Pyramid specify ranges or maximum amounts rather than minimums. Also, specific calorie levels have been identified for various age/sex/activity groups of people.

   Within a total diet system, flexibility of choice for the consumer is given where possible through choices within specific food categories. These food categories have similarities in their content of key nutrients, including their macronutrient composition. For example, the proposed food pattern for the Pyramid allows flexibility of choice within each food group or subgroup and within the categories of additional solid fats, additional oils, and added sugars. Choices made within these categories maintain the overall nutritional profile of the diet.

2. **Defining "Optimal" Dietary Choices:** The Pyramid does not set nutritional policy—it is an educational tool designed to help Americans implement current policy on what constitutes an "optimal" diet. Operationally, an "optimal" diet is defined as meeting the current Dietary Guidelines and Dietary Reference Intakes. Quantified nutritional goals for the Pyramid's food pattern are set according to these standards. In addition, educational messages are developed to provide additional guidance where qualitative, but not quantified, goals are available.

3. **Selection of One Set of "Optimal" Choices:** There is an immense number of food patterns that could meet current nutritional adequacy and moderation goals. How can one set of food choices be selected over another? The premise used in determining food patterns for the Pyramid has been to start with what is actually consumed by Americans and adjust the amounts of various food categories (which include both "food groups" and "subgroups") into healthful proportions. Alterations are made in the amounts recommended from each category until nutrient goals (for adequacy and moderation) are met. Major shifts from actual consumption patterns may occur, but only if they are needed to meet the stated goals. This approach differs from some other food guidance approaches that use different criteria to identify other "optimal" dietary patterns.

4. **Discretionary Fats in the Food Pattern:** Within each food group and subgroup, food items in their lowest fat form are selected for use in determining the nutrient profile of the group or subgroup. However, some amount of fat remains in each group's nutrient profile and is termed **intrinsic** fat. The total amount of all intrinsic fat in the food pattern ranges from about 10 g in the 1,000-calorie pattern to 35 g in the 3,200-calorie pattern. To bring the amounts of total fat and essential fatty acids to recommended levels, a separate component—discretionary fats—is added. Discretionary fats represent the mix of fats that individuals may consume as part of their food choices or add to their food choices. For example, individuals may use portions of their discretionary fat "allowance" to select 1 percent milk rather than fat-free milk and to have mayonnaise on a sandwich.

   As part of the current revision of the food pattern, discretionary fats were separated into two components—"solid fats" and "oils and soft margarines." The solid fat component includes animal fats (beef, pork, chicken, and dairy fats), as well as hydrogenated vegetable fats (shortening and stick margarine). Because the solid discretionary fat component includes a higher percentage of saturated and *trans* fats, as well as cholesterol, the amounts in the food pattern have been restricted to 40 percent of total discretionary fats. This contrasts with the 58 percent of discretionary fats, as typically consumed, that are solid fats. The other component of discretionary fats—oils (soybean, cottonseed, and corn oils) and soft margarines—has been increased to 60 percent in the food pattern. As typically consumed, this component represents 42 percent of total discretionary fats.

Methods

1. An analysis was conducted for each food pattern from 1,000 to 3,200 calories (each included 2 cups of milk). The same amount of solid fat, oil, and added sugars determined for these patterns was also inserted into the pattern containing three servings of milk.
2. For each level of fat (from 20 to 35 percent of calories), the grams of total fat required to reach the appropriate percentage of calories were determined. Then, the intrinsic fat within the food groups was subtracted from the total to determine the amount of discretionary fat allowed.
3. The discretionary fat was divided into solid fat and oil in a ratio of 40 percent solid to 60 percent oil. An exception was made for the 1,000-calorie pattern, which was left at the current consumption percentages of 60 percent solid and 40 percent oil, to allow for whole milk in the diets of young children.
4. The amounts of solid fats and oils were corrected by the factors 0.85 and 0.95, respectively, to account for the fact that fats and oils as eaten are not 100 percent lipid. For example, butter contains some water and milk solids in addition to lipids.
5. The corrected amounts of fats and oils were inserted into the food pattern spreadsheets, with added sugars set to zero. The caloric deficit was calculated, and sufficient added sugars were inserted to bring the total calories up to the target levels.
6. Percentages of the nutritional goals met for all nutrients with each level of fat were calculated.

Summary of Results (see tables for detailed results)

Solid fats and oils contain many nutrients such as vitamin A, vitamin E, sodium, and calcium, in addition to the nutrients that are fat components (essential fatty acids). However, only vitamin E, linoleic acid, α-linolenic acid (ALA), and cholesterol were affected substantially by manipulating the fat content of the food intake pattern.

Few of the food patterns with any level of fat met the RDA for vitamin E. The RDA was met only at 35 percent calories from fat, and then only in the highest calorie patterns (3,000 and 3,200 calories). As would be expected, the percentage of the RDA for vitamin E in an intake pattern increased consistently with additional fat in the pattern.

Levels of linoleic acid and ALA were highly sensitive to the overall fat content of the pattern. At 20 percent of calories from fat, few patterns met the Adequate Intakes (AIs) or were within the Acceptable Macronutrient Distribution Ranges (AMDRs) for these fatty acids. At 25 percent calories from fat, fewer patterns were below the AIs, and all were within the AMDRs. Patterns at 30 and 35 percent calories from fat all met both the AIs and AMDRs.

Because linoleic acid and ALA are found at higher levels in oils than in solid fats, the intake pattern at 20 percent of calories from fat was modified to use only oils and soft margarines in the pattern (no solid fats) to determine whether linoleic acid and ALA could be provided in sufficient quantities at 20 percent of calories from fat. While the results are an improvement over the original 20 percent pattern, the standards for linoleic acid and ALA were not met at many calorie levels.

For this exercise, calories in the pattern were balanced using added sugars. Tables G2-21–G2-24 show the amounts of added sugars in each pattern, in addition to the information provided on fat-related nutrients. Added sugars ranged from 13 to 46 teaspoons (52 to 184 g) at 20 percent of calories from fat to zero to 17 teaspoons (0 to 68 grams) at 35 percent. The amounts of added sugars allowed in the 35 percent pattern are quite limited at most calorie levels.

Additional findings include the following:

- At 20 percent of calories from fat, more than 65 percent of calories were supplied by carbohydrates at the highest calorie levels.
- At 35 percent calories from fat, cholesterol levels were above the standard of 300 mg at the highest calorie levels.

Detailed results are presented in the following tables. Note that some of the information in the tables is presented as a range, because several age/sex groups may have the same caloric needs but different RDAs or AIs. The ranges represent the percentages of the goal for different age/sex groups at that calorie level.

Table G2-21 shows the estimation of the shortfalls and percentage of calories from fat and carbohydrates if the amounts of fat in each pattern were set to 20 percent of calories. The table also presents the approximate amounts in each food pattern. **Results that are less than (or more than) the goal appear in bold.**

Table G2-21. 20 Percent of Calories From Fat

Pattern (20% kcal fat)	Calories From Fat (%)	Calories From CHO (%)	Added Sugars (tsp.)	Vitamin E (% RDA)	Linoleic Acid (% AI)	ALA (% AI)
1000	20	65	13	**45**	**72 (4.6%)**	**74 (0.4%)**
1200	20	64	13	**53**	**67**	**74 (0.5%)**
1400	20	63	15	**59**	**76 (4.9%)**	**82 (0.4%)**
1600	20	62	15	**33-45**	**71-78 (4.6%)**	**70-77 (0.5%)**
1800	20	63	18	**39-54**	**83-90 (4.8%)**	**83-91 (0.5%)**
2000	20	64	18	**43**	**79-92 (4.8%)**	**69-100 (0.5%)**
2200	20	65	23	**46**	**72-76 (4.8%)**	**75 (0.5%)**
2400	20	65	24	**51**	**79**	**82 (0.5%)**
2600	20	**66**	28	**58**	**87**	**92 (0.5%)**
2800	20	**66**	32	**60**	**99**	**98 (0.5%)**
3000	20	**67**	36	**68**	101	**108 (0.5%)**
3200	20	**68**	46	**71**	116	**116 (0.5%)**

*The percentage of calories shown only when less than AMDR. AMDR for linoleic acid is 5-10 percent kcal; AMDR for ALA is 0.6-1.2 percent kcal.

Table G2-22 shows the estimation of the shortfalls and percentage of calories from fat and carbohydrates if the amounts of fat in each pattern were set to 25 percent of calories. The table also presents the approximate amounts in each food pattern.

Table G2-23 shows the estimation of the shortfalls and percentage of calories from fat and carbohydrates if the amounts of fat in each pattern were set to 30 percent of calories. The table also presents the approximate amounts in each food pattern.

Table G2-22: 25 Percent of Calories From Fat

Pattern (25% kcal fat)	**Calories From Fat (%)**	**Calories From CHO (%)**	**Added Sugars (tsp.)**	**Vitamin E (% RDA)**	**Linoleic Acid (% AI)**	**ALA (% AI)**
1000	25	60	10	**53**	**92**	**93**
1200	25	59	10	**63**	**87**	**95**
1400	25	58	10	**71**	100	107
1600	25	57	10	**39-54**	**94**-102	**92**-100
1800	25	59	13	**47-64**	108-118	107-117
2000	25	59	12	**51-52**	103-120	**89**-129
2200	25	60	16	**55**	**94**-100	**97**
2400	25	60	17	**61**	103	106
2600	25	61	20	**68**	112	117
2800	25	61	24	**72**	129	125
3000	25	62	27	**80**	131	137
3200	25	63	38	**84**	150	148

Note: No patterns were less than AMDR for linoleic or ALA.

Table G2-23. 30 Percent of Calories From Fat

Pattern (30% kcal fat)	**Calories From Fat (%)**	**Calories From CHO (%)**	**Added Sugars (tsp.)**	**Vitamin E (% RDA)**	**Linoleic Acid (% AI)**	**ALA (% AI)**
1000	30	55	7	**62**	111	113
1200	30	54	6	**74**	108	116
1400	30	53	6	**83**	124	131
1600	30	53	5	**46-63**	116-127	131-123
1800	30	54	7	**54-74**	134-146	131-143
2000	30	54	6	**60**	149-127	109-158
2200	30	55	9	**64**	116-123	119
2400	30	55	10	**71**	126	130
2600	30	56	12	**79**	138	143
2800	30	56	15	**83**	158	153
3000	30	57	18	**92**	161	167
3200	30	58	27	**98**	184	179

Note: No patterns were less than AMDR for linoleic or ALA.

Table G2-24 shows the estimation of the shortfalls and percentage of calories from fat and carbohydrates if the amounts of fat in each pattern were set to 30 percent of calories. The table also presents the approximate amounts in each food pattern.

A scenario of using oils and soft margarines only in the patterns (no solid fats) was run to determine if linoleic acid and ALA could be provided in sufficient quantities at 20 percent of calories from fat. This analysis was undertaken because the intake pattern with 20 percent of calories from fat, which were split between solid fats (40 percent) and oils/soft margarines (60 percent), were low in both linoleic acid and ALA across almost all calorie levels. Table G2-25 shows the results of this analysis.

Table G2-24. 35 Percent of Calories From Fat

Pattern (35% kcal fat)	**Calories From Fat (%)**	**Calories From CHO (%)**	**Added Sugars (tsp.)**	**Vitamin E (% RDA)**	**Linoleic Acid (% AI)**	**ALA (% AI)**
1000	35	50*	4	**70**	131	132
1200	35	48	2	**84**	128	137
1400	35	48	2	**96**	147	156
1600	35	48	0	**53-72**	139-152	134-146
1800	35	48-49	2	**61-84**	159-173	155-169
2000	35	49	0	**68**	152-177	129-187
2200	35	50	3	**73**	137-146	1140-141
2400	35	50	3	**80**	150	154
2600	35	51	4	**89**	164	169
2800†	35	51	7	**95**	186	181
3000†	35	52	9	105	191	197
3200†	35	53	17	111	217	211

*The 1,000-calorie pattern contained 96 percent of the AI for carbohydrates.
†The 2,800-, 3,000-, and 3,200-calorie patterns contained 310, 314, and 319 mg of cholesterol, respectively.

Table G2-25. 20 Percent of Calories From Fat, With Oils/Soft Margarines Only

Pattern (20% kcal fat)	**Calories From Fat** %	**Calories From CHO** %	**Added Sugars** tsps.	**Vitamin E** % RDA	**Linoleic Acid** % AI (% kcal)	**ALA** % AI (% kcal)
1000	20	65	13	**58**	103	**95**
1200	20	64	13	**60**	**82**	**85**
1400	20	63	15	**67**	**92**	**94 (0.5%)**
1600	20	62	15	**37-50**	**85-92**	**80-87 (0.5%)**
1800	20	63	18	**44-60**	99-108	**94-103 (0.5%)**
2000	20	64	18	**48-49**	94-110	**78-104 (0.5%)**
2200	20	65	23	**52**	**86-91**	**85 (0.5%)**
2400	20	65	24	**57**	**94**	**94 (0.5%)**
2600	20	**66**	28	**65**	105	105 **(0.5%)**
2800	20	**66**	32	**68**	120	112 **(0.5%)**
3000	20	**67**	36	**77**	123	124
3200	20	**68**	46	**81**	143	134 **(0.5%)**

* Percentage of calories shown only when less than AMDR.

Conclusions

The analysis suggests the following advice concerning fat intake:

- Keep fat intake to within 20 to 35 percent of calories as recommended by the DRI report. The proposed food intake pattern across the calorie levels contains 27 to 28 percent of calories as fat, which is approximately midway within this range.
- Replace about half of the solid fats now eaten with oils (and/or soft margarines). The proposed pattern suggests that 40 percent of discretionary fats should be solid fats, about 50 percent less than is now consumed, and that increased oil (and/or soft margarine) intake replace these solid fats.
- Include cautions to ensure an adequate intake of linoleic acid and ALA if an individual chooses to select a diet with less than 27 to 28 percent of calories as fat. Increasing the proportion of oils beyond 60 percent of discretionary fats and selecting oils high in these two fatty acids would help to ensure Adequate Intakes.
- Include cautions to limit cholesterol intake to less than the amounts in the pattern if an individual chooses to select a diet with more than 30 percent of calories as fat.
- Suggest ways to ensure adequate intake of vitamin E, such as choosing oils with high levels of vitamin E, E-rich nuts or seeds, or supplements.

Report on the Food Pattern With 35 Percent Fats and 5 Percent Added Sugars—March 3, 2004

Request From the Carbohydrates Subcommittee

Examine the adequacy of the food pattern with fat at 35 percent of calories and added sugars at 5 percent of calories, with other carbohydrate sources decreased to maintain calorie level.

Rationale for Request

When calories from fat in the food pattern are increased to 35 percent, the amount of added sugars in many patterns drops to almost zero to compensate and maintain calorie levels. Some evidence suggests that keeping added sugars to at least 5 percent of calories is related to improved dietary nutritional quality. In the food pattern with fat at 35 percent and added sugars at 5 percent of calories, would changes in other carbohydrate sources to compensate for the additional calories affect the adequacy of the pattern?

Methods

1. This analysis was an extension of the analysis of various levels of fat in the food pattern and followed similar procedures. It was conducted for each food pattern from 1,000 to 3,200 calories (each included 2 cups of milk). The same amount of solid fat, oil, and added sugars determined for these patterns was also inserted into the pattern containing three servings of milk.
2. The food pattern with 35 percent of calories from fat was used as the starting point. Grams of added sugars required for 5 percent of calories was determined and added to each food pattern. Then, the total calories in the pattern were subtracted from the goal level to determine the caloric difference.
3. For most food patterns, the caloric level with 35 percent fat and 5 percent added sugars exceeded the goal energy level. Enriched grains were selected as the food group to use in compensating to maintain the goal energy level.
4. In each food pattern, the amount of enriched grains to equal the caloric excess was calculated, and the amount of enriched grains in each pattern was reduced by that amount. Amounts were rounded to the nearest 0.5 serving.
5. Percentages of the nutritional goals met for all nutrients were calculated with the modified food pattern.

Results

For most food intake patterns, a decrease of 0.5 to 1 serving of enriched grains was necessary to include both 35 percent of calories as fat and 5 percent of calories as added sugars at the goal calorie level. Profiles from the resulting patterns are presented in Table G2-26:

Table G2-26. Profiles of patterns with 35 percent calories as fat and 5 percent calories as added sugars

Pattern	Calories From Fat (% kcal)	Calories From CHO (% kcal)	Added Sugars (% kcal)	Added Sugars (g)	Enriched Grains in Modified Pattern (servings)	Decrease From Original Pattern (servings)
1000	35	49	5	12	1.5	0
1200	35	48	5	15	1.5	0.5
1400	35	49	5	18	2.0	0.5
1600*	33	48	5	20	2.0	1.0
1800*	34-35	49	5	22	2.5	1.0
2000*	33-35	50-51	5	25	3.0	1.0
2200*	34-35	50	5	28	3.5	1.0
2400	35	50	5	30	4.0	1.0
2600	35	52	5	32	4.5	0.5
2800*	34	51	5	35	5.0	0.5
3000	35	52	5	37	5.5	0
3200*	34	53	9	72	5.5	0

* Percent of calories from fat is less than 35 percent because the pattern with three servings of milk is analyzed at this calorie level. The amount of fat and added sugars in the pattern is based on the pattern with two milk servings.

Enriched grain products contribute important amounts of certain nutrients to the Pyramid food pattern. On average, they provide more than 10 percent of the thiamin, folate, riboflavin, niacin, vitamin B_6, calcium, iron, copper, and fiber in a food pattern.

The decreased amounts of enriched grains in most patterns resulted in slightly lower levels of many nutrients. Some of these nutrients are supplied in amounts well above the nutrient's goal level. For these nutrients, then, the 0.5 to 1 serving decrease in enriched grains did not result in shortfalls. However, for a few age/sex groups and for nutrients that were marginal in the original pattern, the decrease did result in or worsen a shortfall. These shortfall nutrients are shown in Table G2-27.

Table G2-27. Marginal or Shortfall Nutrients in Food Patterns With Modifications for 35 Percent Calories as Fat and 5 Percent as Added Sugars

Nutrient	Food Pattern	Age-Sex Group (sedentary)	Original Proposed Pattern—Amount in Pattern as % of Goal	With Less Enriched Grains—Amount in Pattern as % of Goal
Calcium	1600 (3m)	F 9-13	96%	94%
	1800 (2m)	F 31-50	101%	98%
	1800 (3m)	M 9-13, F 14-18	101%	99%
Iron	1200 (2m)	F 4-8	98%	92%
	1800 (2m)	F 31-50	96%	89%
Fiber	1200 (2m)	F 4-8	97%	95%
	1400 (2m)	M 4-8	97%	95%

Conclusions

The current analysis suggests the following, in addition to the conclusions from the prior analysis of the food pattern at 35 percent of calories from fat:

- The food intake pattern with 35 percent of calories as fat and at least 5 percent of calories as added sugars is feasible for many age/sex groups. To maintain caloric balance, the amount of enriched grains selected can be decreased by 0.5 to 1 serving.
- Some age/sex groups have relatively high requirements for calcium and iron, and if sedentary, relatively low caloric needs. These groups are adult women age 31 to 50 years, girls age 9 to 18 years, and boys age 9 to 13 years. The intake of calcium and iron is already marginal for these groups, and reducing the amount of enriched grains results in or worsens shortfalls.

These vulnerable age/sex groups may need advice on selecting a nutrient-dense diet, especially for calcium and iron. Increasing the amount of fat in the diet to 35 percent may not be compatible with nutrient adequacy for these groups, especially if they are sedentary.

High Omega-3 Fish Analysis—April 16, 2004

Request From the Fatty Acids Subcommittee

What is the impact of increasing fish and/or high omega-3 fish consumption to 8 or 9 ounces per week?

Background

In developing the Pyramid food intake pattern, fish have been grouped with red meats, poultry, eggs, nuts, and seeds into a single food group. The nutrient profile of this group has been calculated by assuming a proportionate intake of each category of food equal to the proportion consumed by the population. The meats and poultry selected as representative items have been the leanest choices within each food type. Food items selected in calculating the nutrient profile have been those whose intake represents more than 1 percent of the total intake of the food group. Other foods (with less than 1 percent intake) in each category are grouped with the most similar food in calculating overall percent consumption. For example, since shrimp is the most widely consumed shellfish, all shellfish have been grouped with shrimp to calculate total shellfish consumption, and shrimp nutrient values have been used to represent shellfish in the nutrient profile.

The original food item groups used in developing the proposed food pattern and percent consumption according to NHANES 1999–2000 data are listed in Table G2-28.

In developing the original nutrient profile for fish, finfish were sorted by overall fat content into lean and fatty item groups, and the most consumed fish in each was selected for use in representing the group. Flounder represented lean finfish, and catfish represented fatty finfish. Tuna was considered a separate item group to represent all canned fish, because its consumption was greater than 1 percent of the overall MPFEN group. As stated earlier, shrimp represented all shellfish.

Because the item groups used for fish were separated by overall fat content rather than omega-3 fatty acid content, a re-grouping of fish into new item groups was necessary to complete the requested analysis.

Table G2-28. Subgroups and item groups in the meat, poultry, fish, egg, and nut (MPFEN) composite according to NHANES 1999–2000 intake data

Subgroups and Item Groups in Each	Percent of MPFEN Consumption
Meats (beef, ground beef, pork, lamb, ham, luncheon meats, and liver item groups)	55.7%
Poultry (chicken and turkey item groups)	24.5%
Fish (lean finfish, fatty finfish, tuna, and shellfish item groups)	8.3%
Eggs	7.8%
Nuts and seeds	3.6%

Methods

1. Using NHANES 1999–2000 consumption data, identify intake for each individual type of fish. Create a separate item group for each individual type of fish consumed (salmon, herring, etc.). Calculate total consumption for each item group.
2. Separate all fish item groups into low omega-3 (LO3) or high omega-3 (HI3) subgroups. The cutoff value for placement into the LO3 or HI3 group was 500 mg of eicosapentaenoic acid (EPA) plus docosahexaenoic acid (DHA) in a 3-ounce serving of the fish. This cutoff was based on the recommendation of the Dietary Guidelines Advisory Committee's fatty acid subcommittee. Addendum A lists the EPA and DHA content of fish used in this analysis.
3. Calculate a nutrient profile for each subgroup, using a weighted average based on the consumption of each item group.
4. Tuna was handled separately because NHANES does not distinguish between types of tuna (light or white). Therefore, all tuna was grouped together to calculate the overall amount consumed. Then, 75 percent of the total amount of tuna consumed was assigned to light tuna and 25 percent to white tuna on the basis of an estimate obtained from ARS. Light tuna was then added to the LO3 group, and white tuna was added to HI3 group. New weights based on consumption were assigned to calculate an overall nutrient profile for each subgroup (low or high omega-3 fish), including tuna.
5. These nutrient profiles were used to calculate two new nutrient profiles for the MPFEN group, assuming an increase in fish or HI3 fish as recommended. Nutrient profiles are based on percent of intake for each subgroup within the overall group. The 8 ounces per week amount was based on the food intake pattern having a total of 5 ounces per day from the MPFEN group. The percentage of the MPFEN group assigned to each subgroup (meat, poultry, etc.) was adjusted to accommodate intake of (1) 8 ounces of fish per week and (2) 8 ounces of HI3 fish per week. For the 8 ounces of fish per week scenario, the ratio between LO3 and HI3 fish was maintained at current intake levels. For the 8 ounces of HI3 fish per week, all fish intake was assumed to be HI3 fish, and LO3 fish intake was set at zero.
6. The two new nutrient profiles were used in the food intake pattern to assess nutrient outcomes, including EPA and DHA intakes. For this analysis, EPA and DHA intakes from foods other than fish were assumed to be zero. Data are not readily available for many foods, and amounts of these fatty acids were assumed to be negligible for other foods included in the food intake pattern.

Results

1. Based on NHANES 1999–2000 consumption data, the majority of fish intake (63 percent) is finfish low in omega-3 fatty acids. The most popular single fish is tuna (22 percent), with shrimp (16 percent), salmon (9 percent), mixed fish (8 percent), and crab (7 percent) also commonly reported. Addendum B lists each type of fish reported in NHANES and also its consumption relative to other fish in its omega-3 group and overall.

   Overall tuna intake was split assuming 25 percent was white tuna (albacore) and 75 percent light tuna, according to estimates of light vs. white tuna consumption. Proportionate amounts were added to the two fish subgroups. Proportionate overall fish intake with tuna added is shown in Table G2-29.

Table G2-29. Fish consumption by subgroup, with tuna in HI3 (25 percent) and LO3 (75 percent) groups

Group	Percent of Total Fish Consumption
	%
HI3 fish	14.35
White tuna (est.)	5.53
HI3 fish with tuna	19.88
LO3 fish	63.53
Light tuna (est.)	16.59
LO3 fish with tuna	80.12
Total	100.00

2. The resulting amounts of EPA and DHA in fish subgroups, including tuna, are shown in Table G2-30. The amounts are weighted averages of the EPA and DHA content of each fish in the group, with weights based on relative consumption of the fish. Values are expressed in grams per ounce of cooked fish, for most fish. For a few fish, only raw values were available and were used.

Table G2-30. EPA and DHA content of fish groupings

	EPA	DHA	EPA Plus DHA
	(g/oz.)	(g/oz.)	(g/oz.)
HI3 fish	0.282	0.125	0.407
LO3 fish	0.048	0.057	0.105

3. New MPFEN nutrient profiles were calculated, including either 8 ounces of total fish or 8 ounces of HI3 fish per week. The proportion of foods in the revised MPFEN nutrient profiles is shown in Table G2-31.

Table G2-31. Proportional intakes for the MPFEN group, assuming recommendations for 8 ounces of fish or 8 ounces of HI3 fish per week

Subgroups	Percent of MPFEN Consumption	
	With 8 ounces total fish per week	With 8 ounces HI3 fish per week
Meats	45.7%	45.7%
Poultry	20.1%	20.1%
HI3 fish	4.6%	22.9%
LO3 fish	18.3%	0.0%
Eggs	7.8%	7.8%
Nuts and seeds	3.5%	3.5%

Using the new MPFEN nutrient profiles, amounts of DHA and EPA in each food intake pattern were calculated. Since other sources of EPA and DHA were considered negligible, only the MPFEN values for these fatty acids are reflected in the total amounts in each food intake pattern. These amounts are shown in Table G2-32.

Table G2-32. EPA and DHA content of food intake patterns, with 8 ounces of fish or 8 ounces of HI3 fish per week

Calorie Level	8 Ounces Fish per Week EPA+DHA	8 Ounces HI3 Fish per Week EPA+DHA
	g	g
1000	0.076	0.186
1200	0.113	0.279
1400	0.151	0.372
1600*	0.189	0.466
1800*	0.189	0.466
2000	0.208	0.512
2200	0.227	0.559
2400	0.246	0.605
2600	0.250	0.615
2800	0.265	0.652
3000	0.265	0.652
3200	0.265	0.652

* Base patterns for analysis with 5 ounces of MPFEN per day. These patterns would include 8 ounces of fish (or HI3 fish) per week. Other patterns would have more or less fish, with approximately 3 ounces per week in the 1,000-calorie pattern and 11 ounces per week in the 3,200-calorie pattern.

4. The impact on other nutrients of substituting more fish or HI3 fish for some meat and poultry was quite small. For most nutrients, no change was evident when expressed as a percentage of the RDA or AI. For iron, a decrease of 2 to 4 percent was seen in the pattern with the 8 ounces of HI3 fish but not in the pattern with 8 ounces of all fish. For several nutrients, a change of 1 to 2 percent was seen, but this did not affect the adequacy of the pattern. Changes in total fat, saturated fat, and cholesterol are shown in Table G2-33.

Table G2-33. Changes in fat content with increase in fish or HI3 fish in selected food patterns

Nutrient/Pattern	Original Amount (g/% kcal)	With 8 Ounces Fish (g/% kcal)	With 8 Ounces HI3 Fish (g/% kcal)
Total fat			
1800	56.2/28%	55.5/28%	57.1/29%
2200	68.5/28%	67.6/28%	69.6/28%
2600	77.3/27%	76.4/27%	78.6/27%
Saturated fat			
1800	14.8/7.5%	14.3/7.3%	14.7/7.4%
2200	18.1/7.4%	17.6/7.2%	18.0/7.3%
2600	20.2/7.0%	19.6/6.9%	20.1/7.0%
Cholesterol	(mg)	(mg)	(mg)
1800	211	209	203
2200	253	251	244
2600	278	275	267

5. Amounts of fish in the suggested pattern relative to actual consumption also were examined. Since fish with HI3 levels are consumed less than other fish, the suggested increase in intake would be greater if 8 ounces of HI3 fish were recommended. Therefore, a comparison was made of the potential increases over actual consumption for both scenarios. The increases are shown in Table G2-34. The potential increase with an intake of 8 ounces of fish recommended is about 5 ounces, which is about 1¾ times additional intake on top of the current intake levels. The increase with a recommended intake of 8 ounces of HI3 fish is about 7½ ounces, which is more than a twelvefold increase above current intake levels.

   An additional consideration in examining current intake levels is that these are national averages, and there are probably widespread regional differences in overall fish intake and in the type of fish consumed. We were not able to consider these factors in the current analysis.

Summary

About 80 percent of current fish intake is from species that are relatively lower in omega-3 fatty acid content. Note that the cutoff level for determining fish that fell into the "HI3" group or the "LO3" group was set at 500 mg per 3-ounce serving, in compliance with a suggestion from the subcommittee.

A recommendation to eat 8 ounces of HI3 fish per week would provide from 186 to 652 mg of EPA and DHA per day combined in the food pattern with 1,000 to 3,200 calories, respectively. A recommendation to eat 8 ounces of fish per week would provide from 76 to 265 mg of EPA plus DHA per day over the same calorie range, if intakes followed current consumption patterns. The recommendation for 8 ounces of HI3 fish per week does differ greatly from current consumption.

Other Considerations and Questions

1. Note that in this analysis no intake of EPA or DHA from sources other than fish, or conversion of ALA to these fatty acids, was considered because of data limitations. How should potential intake from other sources be handled as an alternative to fish consumption?
2. How would any specific recommendation for fish intake apply to vegetarians? What other types of flexibility could or should be considered for any recommendation about fish intake? For example, lactose-free alternatives to milk are being considered for those who are lactase deficient.
3. Given that all other recommendations incorporated into the food patterns have been based on meeting identified nutrient standards set by the IOM, on what standard would a recommendation on fish intake be based?

Table G2-34. Increased intakes—recommendations in comparison to current consumption

Recommendation	Original Intake (oz./wk)	Rec. Intake (oz./wk)	Increase (oz./wk)	Increase (%)
8 oz. fish per week—all fish	2.92	8.00	5.08	174%
LO3 fish	2.34	6.40	4.06	174%
HI3 fish	0.58	1.60	1.02	174%
8 oz. HI3 fish per week	0.58	8.00	7.42	1270%

Addendum A: EPA and DHA Content of Fish Species (Data From NDB SR 16-1)

(Fish listed in bold indicate the form of the fish used in the analysis—usually the most commonly eaten, without added fat.)

Fish Species and Description	DHA per 100 g	EPA per 100 g	DHA+ EPA per 100 g	DHA+ EPA per 85 g (3 oz.)
Crustaceans, crab, Alaska king, cooked, moist heat	**0.118**	**0.295**	**0.413**	**0.351**
Crustaceans, crab, blue, cooked, moist heat	0.231	0.243	0.474	0.403
Crustaceans, crab, Dungeness, cooked, moist heat	0.113	0.281	0.394	0.335
Crustaceans, crab, queen, cooked, moist heat	0.145	0.332	0.477	0.405
Crustaceans, crayfish, mixed species, farmed, cooked, moist heat	**0.038**	**0.124**	**0.162**	**0.138**
Crustaceans, crayfish, mixed species, wild, cooked, moist heat	0.047	0.119	0.166	0.141
Crustaceans, lobster, northern, cooked, moist heat	0.031	0.053	0.084	0.071
Crustaceans, shrimp, mixed species, cooked, moist heat	**0.144**	**0.171**	**0.315**	**0.268**
Crustaceans, spiny lobster, mixed species, cooked, moist heat	**0.139**	**0.341**	**0.480**	**0.408**
Fish, anchovy, European, raw	**0.911**	**0.538**	**1.449**	**1.232**
Fish, anchovy, European, canned in oil, drained solids	1.292	0.763	2.055	1.747
Fish, bass, freshwater, mixed species, cooked, dry heat	0.458	0.305	0.763	0.649
Fish, bass, striped, cooked, dry heat	0.750	0.217	0.967	0.822
Fish, bluefish, cooked, dry heat	0.665	0.323	0.988	0.840
Fish, turbot, cooked, dry heat	0.123	0.09	0.213	0.181
Fish, carp, cooked, dry heat	**0.146**	**0.305**	**0.451**	**0.383**
Fish, catfish, channel, farmed, cooked, dry heat	**0.128**	**0.049**	**0.177**	**0.150**
Fish, catfish, channel, wild, cooked, dry heat	0.137	0.100	0.237	0.201
Fish, caviar, black and red, granular	3.800	2.741	6.541	5.560
Fish, cod, Atlantic, cooked, dry heat	**0.154**	**0.004**	**0.158**	**0.134**
Fish, cod, Pacific, cooked, dry heat	0.173	0.103	0.276	0.235
Fish, croaker, Atlantic, raw	**0.097**	**0.123**	**0.22**	**0.187**
Fish, dolphin fish, cooked, dry heat	0.113	0.026	0.139	0.118
Fish, drum, freshwater, cooked, dry heat	0.368	0.295	0.663	0.564
Fish, eel, mixed species, cooked, dry heat	**0.081**	**0.108**	**0.189**	**0.161**
Fish, fish portions and sticks, frozen, preheated	0.128	0.086	0.214	0.182
Fish, flatfish (flounder and sole species), cooked, dry heat	**0.258**	**0.243**	**0.501**	**0.426**
Fish, grouper, mixed species, cooked, dry heat	0.213	0.035	0.248	0.211
Fish, haddock, cooked, dry heat	**0.162**	**0.076**	**0.238**	**0.202**
Fish, halibut, Atlantic and Pacific, cooked, dry heat	**0.374**	**0.091**	**0.465**	**0.395**
Fish, halibut, Greenland, cooked, dry heat	0.504	0.674	1.178	1.001
Fish, herring, Atlantic, cooked, dry heat	**1.105**	**0.909**	**2.014**	**1.712**
Fish, herring, Atlantic, kippered	1.179	0.97	2.149	1.827
Fish, herring, Pacific, cooked, dry heat	0.883	1.242	2.125	1.806
Fish, lingcod, cooked, dry heat	0.130	0.133	0.263	0.224
Fish, mackerel, Atlantic, cooked, dry heat	0.699	0.504	1.203	1.023
Fish, mackerel, king, cooked, dry heat	0.227	0.174	0.401	0.341
Fish, mackerel, Pacific and jack, mixed species, cooked, dry heat	**1.195**	**0.653**	**1.848**	**1.571**
Fish, mackerel, Spanish, cooked, dry heat	0.952	0.294	1.246	1.059

Fish Species and Description	DHA per 100 g	EPA per 100 g	DHA+ EPA per 100 g	DHA+ EPA per 85 g (3 oz.)
Fish, mullet, striped, cooked, dry heat	**0.148**	**0.18**	**0.328**	**0.279**
Fish, ocean perch, Atlantic, cooked, dry heat	0.271	0.103	0.374	0.318
Fish, perch, mixed species, cooked, dry heat	**0.223**	**0.101**	**0.324**	**0.275**
Fish, pike, northern, cooked, dry heat	**0.095**	**0.042**	**0.137**	**0.116**
Fish, pike, walleye, cooked, dry heat	0.288	0.11	0.398	0.338
Fish, pollock, Atlantic, cooked, dry heat	**0.451**	**0.091**	**0.542**	**0.461**
Fish, pompano, Florida, cooked, dry heat	**??**	**??**	**??**	**0.620 est**
Fish, rockfish, Pacific, mixed species, cooked, dry heat	0.262	0.181	0.443	0.377
Fish, roe, mixed species, cooked, dry heat	**1.747**	**1.26**	**3.007**	**2.556**
Fish, roe, mixed species, raw	1.363	0.983	2.346	1.994
Fish, roughy, orange, raw	0	0.001	0.001	0.001
Fish, sablefish, cooked, dry heat	0.920	0.867	1.787	1.519
Fish, sablefish, smoked	0.945	0.891	1.836	1.561
Fish, salmon, Atlantic, farmed, cooked, dry heat	**1.457**	**0.69**	**2.147**	**1.825**
Fish, salmon, Atlantic, wild, cooked, dry heat	1.429	0.411	1.84	1.564
Fish, salmon, Chinook, cooked, dry heat	0.727	1.01	1.737	1.476
Fish, salmon, chum, cooked, dry heat	0.505	0.299	0.804	0.683
Fish, salmon, chum, drained solids with bone	0.702	0.473	1.175	0.999
Fish, salmon, coho, farmed, cooked, dry heat	0.871	0.408	1.279	1.087
Fish, salmon, coho, wild, cooked, dry heat	0.658	0.401	1.059	0.900
Fish, salmon, pink, cooked, dry heat	0.751	0.537	1.288	1.095
Fish, salmon, sockeye, cooked, dry heat	0.700	0.53	1.23	1.046
Fish, sardine, Atlantic, canned in oil, drained solids with bone	**0.509**	**0.473**	**0.982**	**0.835**
Fish, scup, raw (Porgy—assigned to low omega-3 group)	no data	no data	no data	no data
Fish, sea bass, mixed species, cooked, dry heat	**0.556**	**0.206**	**0.762**	**0.648**
Fish, sea trout, mixed species, cooked, dry heat	0.265	0.211	0.476	0.405
Fish, shad, American, raw	1.321	1.086	2.407	2.046
Fish, shark, mixed species, raw	**0.527**	**0.316**	**0.843**	**0.717**
Fish, sheepshead, cooked, dry heat	0.107	0.083	0.19	0.162
Fish, smelt, rainbow, cooked, dry heat	0.536	0.353	0.889	0.756
Fish, snapper, mixed species, cooked, dry heat	**0.273**	**0.048**	**0.321**	**0.273**
Fish, spot, cooked, dry heat	0.526	0.282	0.808	0.687
Fish, sturgeon, mixed species, cooked, dry heat	0.119	0.249	0.368	0.313
Fish, sucker, white, cooked, dry heat	0.371	0.244	0.615	0.523
Fish, sunfish, pumpkin seed, cooked, dry heat	0.092	0.047	0.139	0.118
Fish, swordfish, cooked, dry heat	**0.681**	**0.138**	**0.819**	**0.696**
Fish, tilefish, cooked, dry heat	0.733	0.172	0.905	0.769
Fish, trout, mixed species, cooked, dry heat	**0.677**	**0.259**	**0.936**	**0.796**
Fish, trout, rainbow, farmed, cooked, dry heat	0.820	0.334	1.154	0.981
Fish, trout, rainbow, wild, cooked, dry heat	0.520	0.468	0.988	0.840
Fish, tuna, fresh, blue fin, cooked, dry heat	1.141	0.363	1.504	1.278
Fish, tuna, light, canned in oil, drained solids	0.101	0.027	0.128	0.109
Fish, tuna, light, canned in water, drained solids	**0.223**	**0.047**	**0.27**	**0.230**

Fish Species and Description	DHA per 100 g	EPA per 100 g	DHA+ EPA per 100 g	DHA+ EPA per 85 g (3 oz.)
Fish, tuna, skipjack, fresh, cooked, dry heat	0.237	0.091	0.328	0.279
Fish, tuna, white, canned in water, drained solids	**0.629**	**0.233**	**0.862**	**0.733**
Fish, tuna, yellow fin, fresh, cooked, dry heat	0.232	0.047	0.279	0.237
Fish, whitefish, mixed species, cooked, dry heat	1.206	0.406	1.612	1.370
Fish, whiting, mixed species, cooked, dry heat	**0.235**	**0.283**	**0.518**	**0.440**
Fish, wolffish, Atlantic, cooked, dry heat	0.405	0.393	0.798	0.678
Frog legs, raw			**0.034**	**0.020**
Mollusks, abalone, mixed species, raw	0	0.049	0.049	0.042
Mollusks, clam, mixed species, cooked, moist heat	**0.146**	**0.138**	**0.284**	**0.241**
Mollusks, conch, baked or broiled	**0.072**	**0.048**	**0.12**	**0.102**
Mollusks, cuttlefish, mixed species, cooked, moist heat	0.132	0.078	0.21	0.179
Mollusks, mussel, blue, cooked, moist heat	**0.506**	**0.276**	**0.782**	**0.665**
Mollusks, octopus, common, cooked, moist heat	**0.162**	**0.152**	**0.314**	**0.267**
Mollusks, oyster, eastern, farmed, cooked, dry heat	**0.211**	**0.229**	**0.44**	**0.374**
Mollusks, oyster, eastern, wild, cooked, dry heat	0.291	0.26	0.551	0.468
Mollusks, oyster, Pacific, cooked, moist heat	0.500	0.876	1.376	1.170
Mollusks, scallop, mixed species, cooked, breaded and fried	**0.103**	**0.086**	**0.189**	**0.161**
Mollusks, whelk, unspecified, cooked, moist heat	0.012	0.008	0.02	0.017

Addendum B: Fish Intake, Grouped by Omega-3 Fatty Acid Content—
From NHANES 1999–2000 (tuna shown as a separate group)

Fish type	Percent of Subgroup Consumption	Percent of All Fish Consumption
High Omega-3 fish	%	%
Anchovy	0.35	00.05
Mackerel	0.23	0.03
Pompano	0.22	0.03
Salmon	61.93	8.87
Sardines	4.81	0.69
Sea bass	12.99	1.86
Swordfish	7.85	1.13
Trout	11.61	1.67
Total—HI3 fish	**100.00**	**14.35**
Low Omega-3 fish	%	%
Carp	0.69	0.44
Catfish	6.58	4.18
Clams	3.85	2.44
Conch	0.15	0.10
Cod	8.08	5.13
Crab	11.76	7.47
Croaker	0.39	0.25
Flounder	7.11	4.52
Frog	0.15	0.10
Haddock	2.23	1.41
Halibut	0.16	0.10
Lobster	1.13	0.72
Mullet	0.59	0.37
Octopus/squid	0.97	0.61
Oysters	1.35	0.86
Perch	1.24	0.79
Pike	1.01	0.64
Pollock	1.99	1.26
Porgy	3.67	2.33
Scallops	1.76	1.12
Shrimp	25.37	16.12
Snapper	0.12	0.08
Whiting	1.58	1.00
Mix of fish	12.72	8.08
Don't know type	5.35	3.40
Total—LO3 fish	**100.00**	**63.53**
	%	%
Tuna—mixed types	**100.00**	**22.12**
OVERALL TOTAL		**100.00**

Nutrient Intakes and Overall Diet Quality in Moderate Drinkers

Research Question

The question posed was "What is the relationship between consuming four or fewer alcoholic beverages daily and calorie and nutrient intakes, overall diet quality (according to the Healthy Eating Index [HEI]), physical activity, and body weight?" or, more specifically, "In 1999–2000, what were the mean nutrient and calorie intakes, overall diet quality scores (HEI), and body mass index (BMI) for men and women in the United States, age 21 years and older, who consumed on average more than zero but less than one, two, three, and four alcoholic beverages per day, respectively?"

The physical activity data (METs codes) from NHANES 1999–2000 have not been released yet so that part of the question was not answered.

Methodology

Operational Definition for Number of Drinks

From the NHANES 1999–2000 dataset, researchers at USDA/CNPP calculated a variable, based on the self-reported average number of alcoholic drinks per drinking day consumed over the past 12 months and the average number of drinking days per month. The categories used in the tabulations were defined as follows:

<1 drink = 0.1–0.49; 1 drink = 0.5–1.49; 2 drinks = 1.5–2.49; 3 drinks = 2.5–3.49; 4 drinks = 3.5–4.49.

Nutrients Tabulated

The NHANES 1999-2000 dataset has about 50 nutrient intake variables, of which 28 were included. They were the nutrients used to develop the new food pattern: energy, protein, carbohydrate, dietary fiber, total fat, saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, linoleic acid, α-linolenic acid, cholesterol, vitamin A, vitamin E, vitamin C, thiamin, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, calcium, phosphorus, magnesium, iron, zinc, copper, sodium (excluding salt added at the table), and potassium. Macronutrient intakes are presented in the following tables, both as a percentage of energy intake and as absolute intakes, and the micronutrient intakes are presented as nutrient densities (per 1,000 kcal) and as absolute intakes.

Results

Among moderate drinkers, age 21 years and older, in the United States in 1999–2000, the BMI generally decreased with increasing amounts of alcohol consumed (Table G2-35). Energy and nutrient intakes generally increased with increasing amounts of alcohol (Table G2-35), whereas nutrient density of the diet generally decreased with increasing amounts of alcohol (Table G2-36). Among women, the HEI increased with increasing amounts of alcohol (Table G2-35), whereas the highest HEI was found among men who consumed an average of two drinks per day.

Some exceptions to these general conclusions were found. Men who consumed three or four drinks per day had lower vitamin A intakes than those who drank less, and the highest calcium intakes were by men who had two drinks per day. Vitamin C intakes by men decreased with increasing alcohol intake. Among women, carbohydrate intake decreased with increasing alcohol intake. Dietary fiber intakes by women consuming two or three drinks per day were lower than those who drank less. Total, saturated, monounsaturated, and polyunsaturated fat intakes were highest (in grams) among women who had an average of one drink per day. An exception for nutrient-density results (Table G2-36) was that magnesium density in the diets of men increased with increasing alcohol intake.

Table G2-37 demonstrates the internal validity of the alcohol data. Mean alcohol intake as measured by 24-hour recalls increased with increasing amounts of alcohol, as determined by self-reported frequency of drinking days over the past year and the average number of drinks consumed per drinking day.

Table G2-35. Estimated Mean BMI, HEI, and Daily Energy and Nutrient Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per day	Sample Size (unweighted)	BMI	SE[a]	HEI	SE	Energy (kcal)	SE
Men:							
<1[c]	631	27.9	0.4	62.8	0.8	2519	52
1	336	26.9	0.4	62.2	0.8	2685	63
2	128	26.8	0.4	64.0	1.6	2728	120
3	78	26.5	0.7	62.9	1.7	3010	174
4	19	28.8	1.1	62.4	3.1	3678	397
Women[d]							
<1[c]	721	27.8	0.4	63.9	0.9	1901	40
1	162	26.9	0.7	63.6	1.4	2066	99
2	46	26.3	0.7	65.9	2.2	1903	96
3	9	25.8	2.5	66.0	4.9	1937	353
4	3	22.9	2.0	70.2	8.8	1979	591

Table G2-35 (cont.). Estimated Mean BMI, HEI, and Daily Energy and Nutrient Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	Vitamin A (mcg RE)	SE	Vitamin E (mg a-TE)	SE	Vitamin C (mg)	SE	Thiamin (mg)	SE	Riboflavin (mg)	SE
Men:										
<1[c]	1007	61	10.3	0.4	108	6	1.94	0.05	2.25	0.06
1	1071	123	10.6	0.5	104	6	1.97	0.08	2.29	0.11
2	963	126	9.4	0.5	90	8	1.97	0.12	2.32	0.12
3	951	212	10.0	0.8	115	12	1.95	0.14	2.47	0.18
4	1164	363	12.6	1.9	[e]	[e]	1.91	0.27	2.70	0.36
Women[d]:										
<1[c]	996	82	9.0	0.4	92	6	1.44	0.05	1.71	0.06
1	1005	103	9.0	0.7	94	11	1.46	0.09	1.83	0.10
2	1029	261	7.4	0.7	79	8	1.33	0.12	1.63	0.10
3	[e]	[e]	[e]	[e]	52	13	[e]	[e]	[e]	[e]
4	[e]	[e]	7.4	2.1	[e]	[e]	[e]	[e]	[e]	[e]

[a]Standard error of the mean.
[b]Excludes salt added at the table.
[c]Greater than 0, but less than 1.
[d]Excludes pregnant and lactating.
[e]Coefficient of variation is greater than or equal to 30 percent.
Source: National Health and Nutrition Examination Survey, 1999–2000

Table G2-35 (cont.). Estimated Mean BMI, HEI, and Daily Energy and Nutrient Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	Niacin (mg)	SE	Vitamin B-6 (mg)	SE	Folate (mcg)	SE	Vitamin B_{12} (mcg)	SE	Calcium (mg)	SE	Phosphorus (mg)	SE
Men:												
<1[c]	26.8	0.6	2.08	0.06	428	14	5.9	0.3	951	34	1504	35
1	30.1	1.2	2.23	0.09	437	16	7.2	1.6	968	38	1581	40
2	29.4	1.6	2.29	0.14	402	24	6.0	0.7	1005	72	1603	75
3	32.0	2.1	2.62	0.21	487	40	5.4	0.7	956	78	1679	100
4	39.5	5.1	3.09	0.48	476	59	[e]	[e]	803	116	1868	281
Women[d]:												
<1[c]	20.1	0.6	1.59	0.06	331	13	4.5	0.4	757	26	1144	32
1	20.9	0.9	1.63	0.08	342	23	3.9	0.3	836	59	1257	55
2	20.6	1.7	1.69	0.18	278	21	4.7	0.7	728	45	1137	58
3	[e]	[e]	[e]	[e]	[e]	[e]	[e]	[e]	1078	283	1272	281
4	[e]	[e]	[e]	[e]	[e]	[e]	4.6	1.1	864	206	1344	317

Table G2-35 (cont.). Estimated Mean BMI, HEI, and Daily Energy and Nutrient Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	Magnesium (mg)	SE	Iron (mg)	SE	Zinc (mg)	SE	Copper (mg)	SE	Sodium[b] (mg)	SE
Men:										
<1[c]	327	8	17.8	0.5	13.6	0.3	1.47	0.03	4131	107
1	344	11	17.8	0.7	14.2	0.4	1.60	0.07	4258	157
2	351	17	17.2	1.2	14.6	1.0	1.56	0.09	4068	202
3	416	28	17.8	1.3	14.5	1.1	1.83	0.12	4444	291
4	476	73	18.0	2.7	[e]	[e]	2.23	0.46	4321	558
Women[d]:										
<1[c]	250	8	13.8	0.5	10.2	0.4	1.15	0.03	3062	71
1	278	13	13.3	0.8	10.2	0.6	1.23	0.06	3243	155
2	274	21	11.4	0.8	10.0	0.8	1.31	0.11	2960	203
3	258	53	[e]	[e]	[e]	[e]	0.94	0.11	2789	505
4	277	81	[e]	[e]	[e]	[e]	[e]	[e]	[e]	[e]

[a]Standard error of the mean.
[b]Excludes salt added at the table.
[c]Greater than 0, but less than 1.
[d]Excludes pregnant and lactating.
[e]Coefficient of variation is greater than or equal to 30 percent.
Source: *National Health and Nutrition Examination Survey, 1999–2000*

Table G2-35 (cont.). Estimated Mean BMI, HEI, and Daily Energy and Nutrient Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	**Potassium (mg)**	**SE**	**Protein (g)**	**SE**	**Carbo-hydrate (g)**	**SE**	**Dietary fiber (g)**	**SE**	**Choles-terol (mg)**	**SE**
Men:										
<1[c]	3137	76	94.8	2.0	314.8	7.4	17.4	0.6	331	13
1	3207	100	101.6	2.7	312.0	10.8	17.7	0.7	344	15
2	3361	164	104.8	5.8	299.9	12.6	16.5	1.1	360	29
3	3651	282	103.0	6.4	324.6	22.2	21.6	2.4	337	32
4	3870	402	131.9	18.4	334.2	25.7	17.6	2.6	485	81
Women[d]:										
<1[c]	2444	73	70.0	1.9	239.8	6.0	13.8	0.6	243	7
1	2671	123	75.9	3.2	247.7	14.5	13.9	0.9	278	23
2	2717	146	73.9	4.4	189.7	12.1	12.3	1.1	282	38
3	2521	621	66.5	12.6	239.5	55.0	11.7	1.9	[e]	[e]
4	[e]	[e]	[e]	[e]		[e]	[e]	[e]	[e]	[e]

Table G2-35 (cont.). Estimated Mean BMI, HEI, and Daily Energy and Nutrient Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	**Total Fat (g)**	**SE**	**Saturated Fat (g)**	**SE**	**Mono-unsaturated Fat (g)**	**SE**	**Poly-unsaturated Fat (g)**	**SE**
Men:								
<1[c]	96.2	2.8	32.2	1.1	37.2	1.0	19.4	0.7
1	101.3	3.2	33.8	1.1	39.6	1.3	20.1	1.0
2	96.4	5.2	32.6	2.0	38.0	2.1	18.4	1.3
3	102.9	7.8	34.1	2.8	40.4	3.2	20.7	1.8
4	130.2	19.3	39.5	6.0	49.0	7.6	31.8	5.3
Women[d]:								
<1[c]	72.7	1.9	24.2	0.7	27.3	0.8	15.8	0.5
1	74.9	4.3	25.4	1.6	28.1	1.6	15.8	1.0
2	67.5	5.6	23.6	1.7	24.7	2.4	14.0	1.7
3	67.1	14.5	23.2	5.4	23.5	5.2	15.9	4.0
4	[e]	[e]	[e]	[e]	23.6	6.2	[e]	[e]

[a]Standard error of the mean.
[b]Excludes salt added at the table.
[c]Greater than 0, but less than 1.
[d]Excludes pregnant and lactating.
[e]Coefficient of variation is greater than or equal to 30 percent.
Source: *National Health and Nutrition Examination Survey, 1999–2000*

Table G2-35 (cont.). Estimated Mean BMI, HEI, and Daily Energy and Nutrient Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	Linoleic Acid (g)	SE	Linolenic Acid (g)	SE
Men:				
<1[c]	17.3	0.7	1.6	0.1
1	17.9	0.9	1.7	0.1
2	16.4	1.2	1.5	0.1
3	18.6	1.6	1.7	0.2
4	27.6	4.6	2.9	0.6
Women[d]:				
<1[c]	14.1	0.5	1.4	0.1
1	13.9	0.9	1.5	0.1
2	12.4	1.5	1.3	0.2
3	13.9	3.5	[e]	[e]
4	[e]	[e]	[e]	[e]

Table G2-36. Estimated Mean Nutrient Intakes, Expressed per 1,000 Kilocalories of Energy Intake or as a Percentage of Energy Intake, for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	Vitamin A (mcg RE per 1000 Kcal)	SE a/	Vitamin E (mg a-TE per 1000 Kcal)	SE	Vitamin C (mg per 1000 Kcal)	SE	Thiamin (mg per 1000 Kcal)	SE	Ribo-flavin (mg per 1000 Kcal)	SE	Niacin (mg per 1000 Kcal)	SE
Men:												
<1[c]	429	27	4.1	0.1	45	3	0.80	0.02	0.92	0.02	11.1	0.2
1	421	43	4.0	0.2	41	2	0.74	0.02	0.86	0.03	11.5	0.3
2	349	44	3.5	0.2	35	3	0.75	0.04	0.86	0.03	11.3	0.5
3	306	53	3.4	0.2	40	4	0.67	0.03	0.84	0.04	11.1	0.7
4	[e]	[e]	3.3	0.3	[e]	[e]	0.51	0.05	0.74	0.05	10.7	0.8
Women[d]:												
<1[c]	546	42	4.7	0.2	51	3	0.77	0.02	0.93	0.03	10.9	0.2
1	508	52	4.4	0.3	50	6	0.73	0.04	0.93	0.05	10.7	0.5
2	539	129	3.8	0.3	42	4	0.73	0.07	0.88	0.04	11.1	0.7
3	[e]	[e]	[e]	[e]	30	6	0.77	0.19	1.11	0.29	10.4	2.4
4	[e]	[e]	3.7	0.2	44	12	1.11	0.17	1.54	0.24	16.5	3.0

[a]Standard error of the mean.
[b]Excludes salt added at the table.
[c]Greater than 0, but less than 1.
[d]Excludes pregnant and lactating.
[e]Coefficient of variation is greater than or equal to 30 percent.
Source: *National Health and Nutrition Examination Survey, 1999–2000*

Table G2-36 (cont.). Estimated Mean Nutrient Intakes, Expressed per 1,000 Kilocalories of Energy Intake or as a Percentage of Energy Intake, for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	**Vitamin B_6 (mg per 1000 Kcal)**	**SE**	**Folate (mcg per 1000 Kcal)**	**SE**	**Vitamin B-12 (mcg per 1000 Kcal)**	**SE**	**Calcium (mg per 1000 Kcal)**	**SE**	**Phos-phorus (mg per 1000 Kcal)**	**SE**	**Mag-nesium (mg per 1000 Kcal)**	**SE**
Men:												
<1[c]	0.86	0.02	175	6	2.5	0.2	384	12	611	10	136	3
1	0.86	0.03	165	5	2.7	0.5	362	12	599	7	132	3
2	0.88	0.05	152	7	2.1	0.2	358	21	588	16	134	7
3	0.88	0.04	163	7	1.9	0.2	330	20	569	20	140	4
4	0.84	0.08	132	9	1.8	0.5	229	35	492	35	127	10
Women[d]:												
<1[c]	0.87	0.03	180	6	2.4	0.2	405	11	615	11	136	3
1	0.85	0.04	177	11	2.0	0.2	409	24	623	20	142	5
2	0.91	0.08	151	11	2.4	0.3	388	22	603	19	147	9
3	0.92	0.26	199	46	[e]	[e]	541	81	648	62	131	11
4	1.59	0.35	[e]	[e]	2.2	0.5	428	58	666	96	137	7

[a]Standard error of the mean.
[b]Excludes salt added at the table.
[c]Greater than 0, but less than 1.
[d]Excludes pregnant and lactating.
[e]Coefficient of variation is greater than or equal to 30 percent.
Source: *National Health and Nutrition Examination Survey, 1999-2000*

Table G2-36 (cont.). Estimated Mean Nutrient Intakes, Expressed per 1,000 Kilocalories of Energy Intake or as a Percentage of Energy Intake, for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	Iron (mg per 1000 Kcal)	SE	Zinc (mg per 1000 Kcal)	SE	Copper (mg per 1000 cal)	SE	Sodium[b] (mg per 1000 Kcal)	SE	Potassium (mg per 1000 Kcal)	SE	Cholesterol (mg per 1000 Kcal)	SE
Men:												
<1[c]	7.3	0.2	5.5	0.1	0.60	0.01	1654	28	1301	26	136	5
1	6.7	0.2	5.3	0.1	0.61	0.02	1601	37	1245	29	133	6
2	6.4	0.4	5.4	0.3	0.59	0.02	1517	67	1283	59	124	6
3	6.1	0.3	5.0	0.3	0.61	0.02	1542	88	1233	85	115	10
4	4.8	0.4	4.8	1.1	0.56	0.05	1178	98	1082	86	134	25
Women[d]:												
<1[c]	7.6	0.2	5.5	0.2	0.63	0.01	1641	23	1341	31	132	4
1	6.8	0.3	5.2	0.3	0.63	0.03	1633	45	1394	58	140	10
2	6.0	0.3	5.2	0.3	0.69	0.05	1557	99	1476	63	143	18
3	6.9	1.9	[e]	[e]	0.52	0.05	1476	153	1253	182	103	23
4	[e]	[e]	[e]	[e]	0.64	0.03	1188	162	1381	148	96	10

Table G2-36 (cont.). Estimated Mean Nutrient Intakes, Expressed per 1,000 Kilocalories of Energy Intake or as a Percentage of Energy Intake, for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	Dietary Fiber (g per 1000 Kcal)	SE	Protein (% Kcal)	SE	Carbohydrate (% Kcal)	SE	Total Fat (% Kcal)	SE	Saturated Fat (% Kcal)	SE	Monounsaturated Fat (% Kcal)	SE
Men:												
<1[c]	7.1	0.2	15.5	0.2	50.2	0.6	33.8	0.5	11.3	0.2	13.0	0.2
1	6.8	0.2	15.5	0.3	46.6	0.8	33.5	0.7	11.1	0.2	13.1	0.3
2	6.3	0.4	15.5	0.6	45.1	1.0	30.6	0.9	10.2	0.4	12.1	0.4
3	7.3	0.6	14.2	0.7	42.8	1.4	31.2	1.6	10.3	0.6	12.2	0.7
4	4.9	0.7	13.9	0.6	37.7	2.8	31.3	2.6	9.5	0.8	11.8	1.1
Women[d]:												
<1[c]	7.6	0.3	15.1	0.3	50.7	0.6	34.1	0.6	11.3	0.2	12.7	0.2
1	7.2	0.5	15.4	0.7	47.5	1.6	32.4	0.9	10.8	0.4	12.1	0.4
2	6.8	0.6	15.7	0.7	41.1	1.9	31.5	1.6	11.1	0.6	11.6	0.7
3	6.2	0.4	13.8	1.6	49.3	4.7	30.7	4.7	10.8	2.0	10.7	1.4
4	[e]	[e]	12.6	1.9	49.6	6.8	29.5	2.4	9.2	0.8	10.7	0.6

[a]Standard error of the mean.
[b]Excludes salt added at the t able.
[c]Greater than 0, but less than 1.
[d]Excludes pregnant and lactating.
[e]Coefficient of variation is greater than or equal to 30 percent.
Source: *National Health and Nutrition Examination Survey, 1999–2000*

Table G2-36 (cont.). Estimated Mean Nutrient Intakes, Expressed per 1,000 Kilocalories of Energy Intake or as a Percentage of Energy Intake for Men and Women age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day	**Polyunsaturated Fat (% Kcal)**	**SE**	**Linoleic Acid (% Kcal)**	**SE**	**Linolenic Acid (% Kcal)**	**SE**
Men:						
<1[c]	6.9	0.2	6.1	0.2	0.6	0.0
1	6.7	0.3	6.0	0.2	0.6	0.0
2	5.9	0.3	5.2	0.3	0.5	0.0
3	6.2	0.4	5.6	0.4	0.5	0.0
4	7.6	0.9	6.7	0.8	0.7	0.1
Women[d]:						
<1[c]	7.5	0.2	6.6	0.2	0.6	0.0
1	7.0	0.4	6.1	0.3	0.7	0.1
2	6.4	0.6	5.7	0.5	0.6	0.1
3	7.1	1.4	6.2	1.2	0.7	0.2
4	7.1	1.2	6.3	1.0	[e]	[e]

[a]Standard error of the mean.
[b]Excludes salt added at the table.
[c]Greater than 0, but less than 1.
[d]Excludes pregnant and lactating.
[e]Coefficient of variation is greater than or equal to 30 percent.
Source: National Health and Nutrition Examination Survey, 1999–2000

Table G2-37. Estimated Mean Alcohol Intakes for Men and Women Age 21 Years and Older Who Drank Moderate Amounts of Alcoholic Beverages in the United States, 1999–2000

Average Number of Drinks per Day[a]	Sample Size (unweighted)	% of Population (weighted)	Alcohol[b,c] (grams)	SE[d]
Men:				
<1[e]	631	38.3	7	1
1	336	22.5	22	2
2	128	9.6	39	5
3	78	5.3	59	13
4	19	1.5	97	27
Women[f]:				
<1[e]	721	42.9	5	1
1	162	11.2	19	4
2	46	3.7	38	4
3	9	0.7	[g]	[g]
4	3	0.4	[g]	[g]

[a]Calculated from self-reported average number of drinks on drinking days and frequency of drinking days over the past 12 months.
[b]Calculated from 24-hour recalls of dietary intake.
[c]12-oz. beer = 12.8-g alcohol; 5-oz. wine = 13.5-g alcohol; 1.5-oz., 80-proof distilled spirits = 14.0-g alcohol.
[d]Standard error of the mean.
[e]Greater than 0, but less than 1.
[f]Excludes pregnant and lactating.
[g]Coefficient of variation is greater than or equal to 30 percent.
Source: *National Health and Nutrition Examination Survey, 1999–2000*

Appendix G-3: Summary Tables from Systematic Review

Although the summary tables from the 2005 Dietary Guidelines Advisory Committee's systematic review are included with this report copy, the printed version of the report will reference the reader to www.health.gov/dietaryguidelines to view these tables.

Appendix G-4: Institute of Medicine Tables

Although the Institute of Medicine tables referenced in the 2005 Dietary Guidelines Advisory Committee Report are included with this report copy, the printed version of the report will reference the reader to www.nap.edu view these tables.

Appendix G-5: History of the *Dietary Guidelines* for Americans

In early 1977, after years of discussion, scientific review, and debate, the Senate Select Committee on Nutrition and Human Needs, led by Senator George McGovern, recommended Dietary Goals for the American people. The Committee recommended that the American diet

- Increase carbohydrate intake to 55 to 60 percent of calories
- Decrease dietary fat intake to no more than 30 percent of calories, with a reduction in intake of saturated fat, and recommended approximately equivalent distributions among saturated, polyunsaturated, and monounsaturated fats to meet the 30 percent target
- Decrease cholesterol intake to 300 mg per day
- Decrease sugar intake to 15 percent of calories
- Decrease salt intake to 3 g per day

The issuance of the Dietary Goals was met with a great deal of debate and controversy from both industry and the scientific community. Both these groups believed the science might not have supported the specificity of the numbers in the Dietary Goals.

To support the credibility of the science used by the Committee, the Department of Agriculture and, at that time, the Department of Health, Education, and Welfare pulled together scientists from the two Departments and expertise from the scientific community throughout the country. In February 1980, the *Dietary Guidelines for Americans* brochure was issued collaboratively by the two Departments and represented their points of view, at that time, on ways to build a healthful diet and lifestyle.

Even though the recommendations of the *Dietary Guidelines for Americans* might have been viewed as relatively innocuous and straightforward extrapolations from the science base, they too were met with a fair amount of controversy. Some of the controversy was generated from industry, some from the scientific community.

The debate about the issuance of the *Dietary Guidelines for Americans* in 1980 led to report language that directed the two Departments to convene a Dietary Guidelines Advisory Committee to ensure that the capture of outside advice was both formal and informal. Hence, the Dietary Guidelines Advisory Committee established shortly after that directive was very helpful in the development of the *1985 Dietary Guidelines for Americans* in which relatively few changes were made but which was issued with much less debate from either industry or the scientific community.

In 1990, with the passage of Public Law 101-445, Congress formally directed the two Departments to issue the guidelines every 5 years. A Dietary Guidelines Advisory Committee was established to assist in the preparations of the 1990, 1995, 2000, and now 2005 versions of the *Dietary Guidelines for Americans*. While there has been a tremendous amount of consistency throughout those guidelines, there have also been some notable changes throughout the years that reflect the emerging science.

Thus, in over two decades, the *Dietary Guidelines for Americans* has evolved to become a broadly accepted document that reflects scientific consensus and provides the statutory basis of Federal nutrition education efforts.

Development of the Dietary Guidelines—A Chronology

1977 *Dietary Goals for the United States* (the McGovern report) was issued by the U.S. Senate Select Committee on Nutrition and Human Needs (1). These goals were the focus of controversy among some nutritionists and others concerned with food, nutrition, and health.

1979 The American Society for Clinical Nutrition formed a panel to study the relationship between dietary practices and health

outcomes (2). The findings, presented in 1979, were reflected in *Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention* (3).

1980 *Nutrition and Your Health: Dietary Guidelines for Americans*, first edition, was issued jointly by the Department of Health and Human Services (HHS) and the U.S. Department of Agriculture (USDA) in response to the public's desire for authoritative, consistent guidelines on diet and health (4). The guidelines were based on the most up-to-date information available at the time and were directed to healthy Americans. The guidelines generated considerable discussion by nutrition scientists, consumer groups, the food industry, and others.

1980 A U.S. Senate Committee on Appropriations report directed that a committee be established to review scientific evidence and recommend revisions to the *1980 Dietary Guidelines* (5).

1983–84 A Federal advisory committee of nine non-Government nutrition scientists was convened to review and make recommendations to HHS and USDA about the first edition of the *Dietary Guidelines for Americans* (6).

1985 HHS and USDA jointly issued a second edition of the *Dietary Guidelines for Americans* (7). This revised edition was nearly identical to the first. Some changes were made for clarity, while others reflected advances in scientific knowledge of the association between diet and a range of chronic diseases. The second edition received wide acceptance and was used as a framework for consumer education messages.

1987 Language in the *Conference Report of the House Committee on Appropriations* indicated that USDA, in conjunction with HHS, "shall reestablish a Dietary Guidelines Advisory Group on a periodic basis. This Advisory Group will review the scientific data relevant to nutritional guidance and make recommendations on appropriate changes to the Secretaries of the Departments of Agriculture and Health and Human Services (8)."

1989 USDA and HHS established a second advisory committee, which considered whether revision to the *1985 Dietary Guidelines* was needed and then proceeded to make recommendations for revision in a report to the Secretaries. The 1988 *Surgeon General's Report on Nutrition and Health* (9) and the 1989 National Research Council's report titled *Diet and Health: Implications for Reducing Chronic Disease Risk* were key resources used by the Committee (10).

1990 The National Nutrition Monitoring and Related Research Act (P.L.101-445) was passed, which requires publication of the *Dietary Guidelines for Americans* every 5 years (11). This legislation also requires review by the Secretaries of USDA and HHS of all Federal publications containing dietary advice for the general public.

1990 HHS and USDA jointly released the third edition of the *Dietary Guidelines for Americans* (12). The basic tenets of the *1990 Dietary Guidelines* were reaffirmed, with additional refinements made to reflect increased understanding of the science of nutrition and how best to communicate the science to consumers. The language of the new *Dietary Guidelines for Americans* was more positive, was oriented toward the total diet, and provided more specific information regarding food selection. For the first time, numerical recommendations were made for intakes of dietary fat and saturated fat.

1993 The HHS Charter established the 1995 Dietary Guidelines Advisory Committee.

1994 The 11-member Dietary Guidelines Advisory Committee was appointed by the Secretaries of HHS and USDA to review the third edition of the *Dietary Guidelines for Americans* to determine whether changes were needed and, if so, to recommend suggestions and the rationale for any revisions.

1995 The report of the Dietary Guidelines Advisory Committee to the Secretaries of HHS and USDA was published (13). This report served as the basis for the fourth edition of *Nutrition and Your Health: Dietary Guidelines for Americans*.

1995 USDA and HHS jointly released the fourth edition of the *Dietary Guidelines for Americans* (14). This edition continued to support the concepts from earlier editions. New information included the Food Guide Pyramid, Nutrition Facts Labels, boxes highlighting good food sources of key nutrients, and a chart illustrating three weight ranges.

1997 The USDA Charter established the 2000 Dietary Guidelines Advisory Committee.

1998 The 11-member Dietary Guidelines Advisory Committee was appointed by the Secretaries of HHS and USDA to review the fourth edition of the *Dietary Guidelines for Americans* to determine whether changes were needed and, if so, to recommend suggestions for revision.

2000 The Committee submitted its report to the Secretaries of HHS and USDA. This report served as the basis for the fifth edition of *Nutrition and Your Health: Dietary Guidelines for Americans*.

2000 The President, USDA, and HHS jointly issued the fifth edition of the *Dietary Guidelines* (15). Earlier versions included seven statements. This version included 10—created by breaking out physical activity from the weight guideline, splitting the grains and fruits/vegetables for greater emphasis, and adding a new guideline on safe food handling.

2003 The HHS Charter established the 2005 Dietary Guidelines Advisory Committee.

2003 The 13-member Dietary Guidelines Advisory Committee was appointed by the Secretaries of HHS and USDA to review the fifth edition of the *Dietary Guidelines for Americans* to determine whether changes were needed and, if so, to recommend suggestions for revision.

2003–04 In keeping with the current emphasis on data quality, a systematic review of the scientific literature was conducted to develop the Committee's recommendations.

2004 The Committee submitted its report to the Secretaries of HHS and USDA. This report will serve as the basis for the sixth edition of *Nutrition and Your Health: Dietary Guidelines for Americans*.

2005 HHS and USDA will jointly issue the sixth edition of the *Dietary Guidelines for Americans*. This publication will continue to serve as the basis of Federal nutrition policy. Additional consumer communication materials will be developed to provide advice to consumers about food choices that promote health and decrease the risk of chronic disease.

References

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4. U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Nutrition and Your Health: Dietary Guidelines for Americans.* Home and Garden Bulletin No. 232, 1980.

5. U.S. Senate Agricultural Appropriations Committee, 96th Cong., 1st sess., 1980, S. Rep. 1030.

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7. U.S. Department of Agriculture and U.S. Department of Health and Human Services.

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8. U.S. House of Representatives Conference Committee, 100th Cong., 1st sess., 1987, H. Rep. 498.

9. U.S. Department of Health and Human Services, Public Health Service. *The Surgeon General's Report on Nutrition and Health.* DHHS (PHS) Publication No. 88-50215, 1988.

10. National Academy of Sciences, National Research Council, Food and Nutrition Board. *Diet and Health: Implications for Reducing Chronic Disease Risk.* Washington, DC: National Academy Press, 1989.

11. National Nutrition Monitoring and Related Research Act of 1990, Public Law 445, 101st Cong., 2d sess. (October 22, 1990), section 301.

12. U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Nutrition and Your Health: Dietary Guidelines for Americans,* 3d ed. Garden Bulletin No. 232, 1990.

13. U.S. Department of Agriculture, Agricultural Research Service, Dietary Guidelines Advisory Committee. *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans,* 1995.

14. U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Nutrition and Your Health: Dietary Guidelines for Americans,* 4th ed. Garden Bulletin No. 232, 1995.

15. U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Nutrition and Your Health: Dietary Guidelines for Americans,* 5th ed. Garden Bulletin No. 232, 2000.

Appendix G-6: Summary of Recommendations From Written Public Comments

The Dietary Guidelines Advisory Committee (DGAC) accepted public comments in written form throughout its charter; a total of 435 submissions were received. Many submissions contained information for consideration, but not specific recommendations. A total of 377 submissions with recommendations for the Committee were received. Although only those submissions with recommendations received before May 12, 2004, are summarized here, the Committee members were provided with copies of all public comments through August 10, 2004. Written public comments were received from individuals, interest groups, industry, academia, and state and Federal Government agencies. Of these 377 submissions, 172 were copies of a form letter (or slight variations on the form letter language) from the Dr. Joseph Mercola's No-Grain Diet Web site.

Some individuals presented public comments as oral testimony during the January 28–29, 2004, meeting of the Committee. These comments are summarized in the minutes of that public meeting (*www.health.gov/dietaryguidelines/dga2005/minutes01_2829_2004.htm*).

All public comments were distributed to the entire Committee for review. Public input helped the Committee gather background information and understand consumer perceptions, and the input helped ensure consideration of important topics.

The following is a summary of the specific recommendations, other comments, and suggested resource materials that were submitted in writing by the public. The material is organized in the following categories:

- General Recommendations: Format, Scope, Target Audience, Process, Implementation, Communication, Content of Dietary Guidelines
- Healthy Weight
- Physical Activity
- Food Guide Pyramid/Variety
- Grains
- Fruits and Vegetables
- Dairy/Calcium
- Meat/Protein
- Food Safety
- Fats
- Sugars
- Salt
- Alcoholic Beverages
- Suggested Resources

When submissions included recommendations or other kinds of comments on more than one topic, which often was the case, the comments were separated and placed in the appropriate category. When more than one person or organization made a comment, the number in parentheses following the comment indicates the number of persons doing so. (In cases in which the same comment was received by more than five commenters, this is indicated by "numerous.") Suggested resource materials are listed by title in the last section of this Appendix.

General Recommendations

Format

A lot of the language is too basic for Americans; use the space to say something more meaningful.

Change the name of the *Dietary Guidelines* to "the Dietary and Physical Activity Guidelines." (2)

Create two separate documents: one for consumers and one for policymakers.

Consider the *Dietary Guidelines* and the Food Guide Pyramid as two prongs to promote eating behavior change in the population.

Scope

Provide dietary advice that is easily understood and applicable to the American public. (2)

Make the *Dietary Guidelines* relevant for consumers today. (2)

Make suggestions for following the *Dietary Guidelines* relevant to consumers' lifestyles. (3)

Set realistic goals to achieve change in consumer behaviors.

Keep the message of how to fit eating healthfully into your life simple.

Consider the *Dietary Guidelines* and Food Guide Pyramid as two prongs to promote eating behavior change in the population.

Encourage harmonization between the Food Guide Pyramid, *Dietary Guidelines*, and Nutrition Facts Panel. (2)

Harmonize the *Dietary Guidelines* with Canadian, European, and World Health Organization guidelines.

The *2005 Dietary Guidelines* must comply with the Information Quality Act.

Use a grading system for scientific information so that the "best" information is brought to the forefront.

Don't be influenced by the current state of American food industries. (2)

Use the results of scientific research in setting the *Dietary Guidelines*. (Numerous)

Basing the *Dietary Guidelines* on scientific evidence will boost the public trust in the *Dietary Guidelines*. (2)

Don't base the *Dietary Guidelines* on scientific developments only; scientific studies can produce scientific rationale for conflicting advice.

Set aside the idea of not making changes so not to confuse the public; "follow the evidence."

Don't try to make *Dietary Guidelines* fit all individuals. There isn't a "one size fits all" diet. (2)

Remove the focus on calories and focus instead on food choices and serving sizes.

Insert the words "calorie" and "calories" into the text and further change the text to match language used by Americans.

Emphasize the relationship between energy intake (calories) and energy expenditure (physical activity), as well as the message that all foods and beverages in moderation fit in a balanced diet and healthy lifestyle.

Consider the research that shows that making small changes in consumption and activity patterns can have a positive impact on health.

Focus on improving the overall quality of the American diet. Correct deficiencies; don't simply focus on "excesses."

Continue emphasis on overall dietary patterns.

Deal with the "explosive" amount of information and advertising/marketing in the food environment.

Target Audience

Revise the *Dietary Guidelines* to meet the unique nutritional needs of the diverse groups of the United States and the important need for cultural literacy and competency in the development of the nutrition education materials and initiatives.

Provide realistic, culturally appropriate approaches and messages to minority and underserved audiences.

The *Dietary Guidelines* should be intended for healthy Americans.

Have separate guidelines for the elderly.

Develop separate guidelines for children, adults, and seniors.

Create separate guidelines for the treatment of obesity.

Present population-level dietary guidance along with messages for the public that lead to positive behavior change at the individual level.

It is inappropriate to use a sedentary, reference-sized individual to determine the target calorie levels. (2)

The use of sedentary, reference-sized individuals in assigning target calorie levels is appropriate.

Use "low-active" rather than sedentary energy levels as the target for recommendations.

Help make our schools models of the latest and best health practices.

Make recommendations for foods and beverages to be served in school settings.

Process

Government should not be involved in deciding on *Dietary Guidelines for Americans*.

Part of the Dietary Guidelines Advisory Committee process must be to clarify the standard of evidence that is appropriate for policy guidance in the nutrition area.

Implementation

Test the *Dietary Guidelines* and related materials with target audiences. (2)

Evaluate the impact of the *Dietary Guidelines* at periodic intervals.

The *Dietary Guidelines* must have clear measurement and evaluation.

What evidence exists to assert that the *Dietary Guidelines* and Food Guide Pyramid are effective public health policy and communication tools?

Implementation of *Dietary Guidelines* should trigger behavioral change.

Include a section in the *Dietary Guidelines* explaining how consumers should interpret news stories on nutrition and diet studies.

The *Dietary Guidelines* are ambiguous and lack concrete, actionable steps. Recommend the application of nutrition education behavioral and theoretical models to be put into practice by recommending actionable consumer language.

Communication

Include in the *Dietary Guidelines* report a communication plan, including a plan to evaluate the effectiveness of the messages and outreach.

Prepare the consumer for continuing advancements in science and consequent additional revisions of the *Dietary Guidelines* in the future.

Encourage public/private partnerships to help communicate the *2005 Dietary Guidelines*.

Consider the practicalities of food science and consumer behavior and education.

Use simple, accurate messages.

Guidelines should provide educators and parents with tools to be good role models.

Guidelines must be supported by nutrition and education programs.

Any discussion on discretionary calories must identify a baseline diet, which may be best done with an interactive Web tool that allows Americans to assess remaining calories after Food Guide Pyramid choices.

Content of Dietary Guidelines

General

Revise the guidelines; evidence exists that following the existing guidelines would result in dietary patterns that are nutritionally inadequate.

Stop promoting three meals a day.

Lack of fiber and too much unhealthy fat should be mentioned in warnings in the *Dietary Guidelines*.

Investigate the effects of carbohydrates on blood sugar, insulin, and obesity.

Be realistic in recommendations about discretionary calories so as not to target any one food or food group.

The DGAC should use Estimated Average Requirement (EAR) instead of Recommended Daily Allowance (RDA) as the basis for setting nutrient goals for the population.

The RDAs and Adequate Intakes (AIs) are the correct numbers to use in all types of planning for individuals and are the appropriate targets in the design of the Food Guide Pyramid and the *Dietary Guidelines*.

Confirm the Department of Health and Human Services (HHS) Small Steps approach as a matter of public health policy.

Risk Reduction

Cite specific examples of how a diet following the *Dietary Guidelines* has been shown to reduce the risk of chronic diseases.

Discuss how grains, sugars, and carbohydrates contribute to most of the major diseases.

Make recommendations for a diet that can be used to control insulin and diabetes.

Recommend a low-fat, plant-based diet for the prevention of cardiovascular disease.

Enjoyment of Food

Recommend home-cooked meals with family and enjoying three good meals a day.

Stress that food consumption activities should be fun and cooking and eating can be enjoyed as a family.

Discuss the impact of eating meals as a family as a lifestyle goal.

Guidelines must recognize the role that enjoyment of food plays in our lives.

Serving/Portion Sizes

Serving sizes in the *Dietary Guidelines*, Food Guide Pyramid, and Nutrition Facts Panel should be harmonized. (3)

The Dietary Guidelines should more clearly define what "a serving" means. People are eating too much because the serving suggestions of the *Dietary Guidelines* and Food Guide Pyramid are confusing and most people consider a "serving" to be bigger than what is meant in the *2000 Dietary Guidelines* and the Food Guide Pyramid.

Serving sizes should be listed in grams. If it is decided to list them by volume (i.e., cups), both volume and mass (in metric units) should be listed.

It is not appropriate to use quantities (cups and ounces) instead of servings.

List quantities in cups and/or ounces instead of servings.

Include the weight of recommended servings in grams and ounces.

Focus on serving sizes and "food exchanges."

Promote moderation in portion size.

Stress sensible portion sizes.

Stress the importance of portion control in a meaningful way.

Address satiety/hunger cues and portion control.

Specific Foods/Nutrients

Base the *Dietary Guidelines* on a diet that will provide an adequate nutrient intake.

Set realistic consumption levels for sugars and fats.

Consider the difficulty of meeting the new Institute of Medicine (IOM) requirements for potassium when making a potassium recommendation.

Consider peanuts and peanut butter as "good sources" of vitamin E that can help Americans meet current recommendations for vitamin E.

List peanuts and peanut butter in addition to nuts as foods that contain healthy unsaturated fat in the *2005 Dietary Guidelines*.

Let the Dietary Reference Intakes (DRI) science set the standard for micro- and macronutrient intake goals.

Ensure adequate intake of vitamin E according to the DRI set by IOM and identify plant oils as sources of dietary vitamin E.

Recommend options for consuming 400 micrograms of synthetic folic acid daily, either from a multivitamin that contains 400 micrograms of folic acid or from fortified foods.

Discuss the role of rice as a means to increase consumption of vegetables and legumes.

Stress that strawberries provide nutrients not found in other fruits; strawberries should be 1 of the 5 to 10 fruits and vegetables consumed each day.

Encourage the consumption of nutrient-rich, low-energy dense foods like mushrooms.

Recommend at least one serving of plant protein a day.

Recommend less than one serving of French fries a week.

Include almonds in the guidelines. Almonds are an excellent source of vitamin E and heart-healthy monounsaturated fat.

Cite avocados as an example when emphasizing the importance of consuming a variety of health-promoting fruits and vegetables in the *Dietary Guidelines*.

Clarify the different benefits of refined grains, such as pasta, for a healthy diet, and help consumers understand that pasta is a vehicle for nutritious and healthy weight management. (2)

Recommend two servings of fatty fish per week.

Set realistic consumption levels for sugars and fats.

Include a statement that soy foods have been identified as an important dietary factor in decreasing risk for cardiovascular disease by lowering LDL cholesterol and increasing arterial compliance.

Remove all soy products from both animal and human diets until they are granted generally-recognized-as-safe (GRAS) status.

Remove any mention of soy foods from the *Dietary Guidelines*.

Recommend research on a diet including soy foods.

Address genetically modified foods in the *Dietary Guidelines*.

Recommend that genetically modified foods be avoided in the American diet. (2)

Include information on organic foods in the *Dietary Guidelines*, including a definition of organic.

Stress the importance of consuming organic foods.

Recommend the consumption of organic foods as opposed to "chemically nourished foods."

Discourage the consumption of processed foods, especially foods high in high-fructose corn syrup (HFCS) and *trans* fats.

Remove any kind of processed food from the *Dietary Guidelines*. Processed foods in general are responsible for an increased prevalence of a variety of diseases.

Recommend the consumption of whole foods instead of processed foods. (4)

Restrict processed, refined, or synthetic foods.

Recommend low consumption of processed foods.

Supplements

Stress that dietary supplements do not take the place of fruits and vegetables or other whole foods.

Include a statement about the fact that multivitamins, as a complement to a healthy diet, are a simple, safe, and cost-effective preventive measure.

Recommend the use of a daily multivitamin for the elderly.

Consider advising Americans about the role that a simple and inexpensive daily multivitamin can play in promoting health and helping prevent disease.

Address the need for a recommendation from a healthcare provider before taking a dietary supplement.

Consider multivitamin use as a complementary means for all Americans to help meet nutrient needs, especially lower income, less educated subgroups of our population.

Healthy Weight

Scope

The focus should be on energy balance.

There should be separate *Dietary Guidelines* intended for weight loss.

Address the continued imbalance between food consumption and activity.

Focus on healthy food choices and not weight management.

Put the emphasis on prevention in this section of the *Dietary Guidelines*. (2)

The weight guideline in the *2000 Dietary Guidelines* should be maintained.

The DGAC should shift focus from "added sugars" to the importance of physical activity and promote moderation in portion size in maintaining healthy body weight.

Do not overemphasize physical activity over diet as the primary cause of overweight and obesity.

Content

General

Give specific advice regarding safe, effective ways to achieve and maintain a healthy weight while reducing chronic disease risk.

Children

Decrease the grains recommendation for children. Six to eleven "bread servings" is too much for the predominantly sedentary lifestyle of today's youth and is contributing to obesity in youths.

Stress that good eating habits should be established early in life to prevent overweight and/or obesity.

Stress that banning soft drinks in schools will not solve the childhood obesity problem.

Obesity/Weight Loss

Although the *Dietary Guidelines* are not a treatment guide for obesity, it would be inappropriate not to address obesity.

By addressing the needs of the overweight and obese, the DGAC also will be addressing the needs of healthy Americans.

Neither the *Dietary Guidelines* nor the Food Guide Pyramid need revision to affect the obesity issue—people just need to start following them!

Encourage the use of nuts in weight maintenance and stress the fact that the consumption of high-fat nuts does not contribute to overweight and obesity.

Make the connection between diet/overweight/obesity and diseases.

Advise consumers to avoid products that claim they cause weight loss without changing diet.

Thoroughly examine all the available science on weight management as the Committee updates the *Dietary Guidelines*.

Specific Types of Diets

Acknowledge current diet trends and provide advice to help consumers choose among them. (2)

Add a guideline in response to fad diets. (2)

Instruct consumers that fad diets that recommend focusing on one group of macronutrients can be dangerous.

The carbohydrate intake controversy should be addressed in the *Dietary Guidelines*. (2)

Make accommodations for low-carbohydrate lifestyles in the *Dietary Guidelines*.

The DGAC should recommend a diet low in both grain products and sugar. (Numerous)

The *Dietary Guidelines* should warn of the dangers of low-carbohydrate, high-protein, and high-fat diets. (2)

The *Dietary Guidelines* should not promote a diet low in carbohydrates.

Inform consumers that low-carbohydrate foods can still contribute to weight gain.

Warn consumers that low-carbohydrate diets are low in fiber.

Warn consumers against the use of high-protein, carbohydrate-restricted diets.

Research continues to support the idea that high-carbohydrate diets that include dietary fiber are linked to reduced body weight.

The DGAC should recommend further study of low-carbohydrate diets and possible inclusion of them in the *Dietary Guidelines* as an option for healthy weight loss.

Advocate the "No-Grain Diet"—replacing grain carbohydrates with vegetable greens and limiting or avoiding sugar. (Numerous)

The DGAC should define carbohydrates and establish a daily reference value for carbohydrates so manufacturers can make nutrient content claims.

Physical Activity

Scope

Physical activity should be an integral part of the *2005 Dietary Guidelines.*

Amplify attention to physical activity in the *Dietary Guidelines.* (3)

Reduce the emphasis on exercise and physical activity in the *Dietary Guidelines.*

Explain the concept of energy balance and how physical activity fits into the equation. (4)

Integrate recommendations about energy intake with energy expenditure.

Promote a physically active lifestyle. (Numerous)

Content

Either increase the amount of physical activity in schools or decrease the amount that sedentary children are fed.

Physical activity goals should be set in the *Dietary Guidelines* similar to the nutritional goals in developing the daily food patterns.

Discuss physical activity in terms of raising the metabolic rate and not in terms of earning extra calories to eat.

Consider including the following statement: "Individuals need to develop individual lifestyle plans that allow them to make small changes over time in eating and physical activity patterns that cumulatively move them closer to living consistent with the *Dietary Guidelines.*"

Provide examples of what types of activities count as physical activity.

Encourage limiting TV and video game time.

Consider a separate conclusive statement on energy balance: "To achieve optimum health, individuals need to achieve personal energy balance by monitoring and matching caloric intake with physical activity levels."

Use a comprehensive approach to energy intake and energy expenditure.

Food Guide Pyramid/Variety

Scope

Continue to emphasize the importance of selecting a variety of choices.

Content

Pyramid Details

Be more specific in examples provided in the "aim for variety" section. The Food Guide Pyramid should be abandoned in favor of returning to the concept of the four food groups. (4)

Remove the Food Guide Pyramid from the new *Dietary Guidelines* or revise it extensively. (3)

Do not revise the Food Guide Pyramid.

Structure the Food Guide Pyramid with fruits and vegetables at the base, meats, nuts, and dairy in the middle, and carbohydrates at the top.

Put vegetables and fruits at the base of the Food Guide Pyramid.

The new Pyramid featured in the January 20, 2003, issue of *Newsweek* is better for health than the current Food Guide Pyramid.

Recommend the Food Pyramid in the book *Enter the Zone*.

Use a different shape for the Food Guide Pyramid.

Change the Food Guide Pyramid to accurately reflect the detail in the *Dietary Guidelines*. The statement "Let the Pyramid Guide Your Food Choices" is inadequate to account for the different types of fats, protein, and other nutrients in different foods from the same section of the Food Guide Pyramid.

Replace "Let the Pyramid Guide Your Food Choices" with "Choose a Diet Built From Plant Foods."

Separate grains from carbohydrates both on the Food Guide Pyramid and the food label.

Reaffirm the role of carbohydrate-containing foods in the American diet.

Shift legumes and starchy vegetables to the grain group in the Food Guide Pyramid.

Include legumes only in the meat group of the Food Guide Pyramid.

Add more nondairy sources of calcium to the dairy group of the Food Guide Pyramid and rename it the "Non-Dairy and Dairy Protein and Calcium Group." (2)

Include pictures of nondairy calcium/milk alternatives in the dairy section of the Food Guide Pyramid.

Add more non-animal-based sources of protein to the meat and beans group and rename it "Meat, Poultry, Fish, Eggs, Dried Beans, and Nuts (non-Animal and Animal Protein, Mineral, and Vitamin Sources)."

Consider adding almonds to the graphic for the meats and beans group of the Food Guide Pyramid.

Fruits and vegetables have different glycemic indices and as such should be in different groups on the Food Guide Pyramid.

Separate fruits and vegetables on the Food Guide Pyramid and limit fruits.

Revise the fruits graphic on the Food Guide Pyramid to include more than just the three fruits currently shown.

Specifically state "whole grains" in the base of the Food Guide Pyramid. (3)

Recommend a Food Guide Pyramid with less emphasis on grains. (2)

Recommend minimizing the intake of grains and sugars in the Food Guide Pyramid and *Dietary Guidelines*. (2)

Eliminate added sugar from the Food Guide Pyramid entirely. (2)

Suggest limits for foods at the tip of the Food Guide Pyramid.

Suggest that the Food Guide Pyramid be positioned on "a solid base of physical activity."

Include physical activity as a section of the Food Guide Pyramid.

Include a guideline for the consumption of pure, clean water.

Include water consumption guidelines in the *Dietary Guidelines* and Food Guide Pyramid.

Advocate a diet low in high-glycemic-index foods.

Cite specific examples of how a diet deficient in certain nutrients can cause short- and long-term developmental problems in children.

Stress food choices from all Food Guide Pyramid groups—not plant-based foods only—because each group provides essential nutrients that others do not.

Refined, processed, irradiated, and genetically modified foods have no place in the *Dietary Guidelines*.

Food Choices

The *Dietary Guidelines* should provide positive dietary guidance to consumers that allows for flexibility and choice as part of a realistic and healthy lifestyle that can be maintained over time.

The critical message from the *Dietary Guidelines* should be that people need to meet their nutrient needs within their energy needs.

Consider a new guideline that instructs consumers to "Choose Foods That Are Naturally Nutrient Rich First." (2)

The DGAC should recommend that consumers eat more foods that are naturally nutrient rich. (2)

Recommend inclusion of the concept of nutrient density of whole foods.

Make recommendations in terms of whole foods. (2)

Introduce an index called calories for nutrition (CFN) that will help consumers choose nutrient-rich foods.

Rather than listing nutrients to avoid (i.e., saturated fats), give specific examples of foods typically high in the nutrients to avoid.

Expand the *Dietary Guidelines* to specifically reference "powerhouse" fruits and vegetables.

Emphasize quality choices within each food grouping.

Place an emphasis on food quality within each group and identify nutrient-rich foods.

Emphasize quality and not quantity or category. (2)

Distinguish between foods with poor nutritional quality and high nutritional quality.

Use "eat less" or "limit" for foods of poor nutritional quality.

There are no good and bad foods; all foods fit into a diet according to the *Dietary Guidelines*.

Emphasize the relationship between energy intake and energy expenditure as well as a message that all foods and beverages in moderation fit into a balanced diet and healthy lifestyle.

Add a guideline stating clearly that some foods and drinks are better for health than others.

Stop avoiding the issue of differentiating between good and bad foods and admit that some foods are less healthful than others.

Stress in the *Dietary Guidelines* that canned foods are nutritionally comparable to other food forms; they are packaged as a convenient, safe, and affordable way to get nutrients.

Endorse the consumption of carbohydrates, including both whole-grain and refined-grain foods, with appropriate quantities of proteins and fats.

Include information on food allergies and sensitivities.

Do not tell people to eat cereal to get iron and calcium.

Vegetarian Diets

Encourage a diet based on plant foods and not animal-derived products.

Encourage the consumption of vegetarian and vegan diets; such diets come closer to meeting the *Dietary Guidelines* than nonvegetarian diets.

Recommend a vegetarian/vegan diet. Vitamin B_{12} deficiency is the only defensible criticism of a vegan diet.

Place more emphasis on the benefits of a vegetarian diet. (2)

Explicitly endorse a low-fat vegetarian diet as the healthiest diet available rather than just stating that vegetarian diets can be consistent with the *Dietary Guidelines*.

Recommend a more prominent vegan/vegetarian influence in the *Dietary Guidelines*.

Grains

Scope

Maintain the current levels of carbohydrates and grains as part of a healthy diet.

Change "Choose a variety of grains daily, especially whole grains" to "Choose whole grains whenever possible."

Change the statement "Choose a variety of grains daily, especially whole grains" to "Choose a variety of whole grains daily."

Reduce the breads and cereals recommendation to 5 to 10 servings per day.

Content

General

Recommend research that shows that wheat products are harmful. (2)

Replace grains with vegetable greens in the *Dietary Guidelines*.

Recommend a diet with limited grain consumption. (Numerous)

Stress that consumers need to eat different grains, not more grains.

Give examples of healthy and unhealthy grains. Ensure that the value of all grains is emphasized in the final recommendations.

Focus on concepts such as the quality and quantity of carbohydrates for consumer understanding.

Recommend a diet devoid of grain products of any kind. (2)

Whole Grains

Strengthen the whole-grain recommendation in the *Dietary Guidelines*.

Encourage the consumption of whole grains in the diet. (3)

Define "whole grain" and advise consumers about how to identify whole-grain products.

Stress that whole grains in the diet protect against many diseases. (3)

Explain that whole-grain carbohydrates are a healthier alternative to refined carbohydrates.

Stress that even though bran cereals are not "whole grains," consumption of them provides the bran that is missing in refined grains.

Differentiate between whole grains and refined grains.

Enriched Grains

Explain what the "enriched" in enriched pasta means.

Explain that reducing consumption of enriched, fortified grains will affect nutrient consumption by removing nutrients with which these grains are currently fortified; this must be considered in dietary recommendations.

Emphasize the importance of fortified and enriched grains as part of a healthful diet.

Processed "Refined" Grains

Explain what the "refined" in refined grains means.

Recommend the elimination of processed grains. (2)

Recommend a diet low in processed grains. (4) Eliminate starches and refined, simple carbohydrates. (2)

Remove processed carbohydrates from the *Dietary Guidelines*; processed carbohydrates are devoid of minerals and vitamins.

Position refined grains in the "use sparingly" category.

Glycemic Index

Explain the glycemic index: "The glycemic index ranks carbohydrates by the speed they enter the blood stream and stimulate insulin. Whole-grain foods have a lower glycemic index than sugar and refined grains. Whole grains provide long-lasting energy and need less insulin."

Include a statement that pasta is a low-glycemic-index food and is a good source of folic acid and other important nutrients.

Recommend a diet low in sugar and processed, high-glycemic-index carbohydrates.

Fruits and Vegetables

Scope

Recognize that fruits and vegetables are currently underconsumed and aggressively promote them.

Continue to have the fruit and vegetable guideline: eat 5 to 10 servings a day. (4)

Recommend consumption of more servings of fruits and vegetables in the *Dietary Guidelines*. (4)

Content

General

Recognize and explain the important and unique role fruits and vegetables play in health promotion and disease prevention.

Emphasize the benefits of consuming a wider variety of fruits.

Make recommendations for how to choose vegetables and fruits to get necessary nutrients.

Explain that fried vegetables are not a substitute for fresh vegetables.

Suggest that people eat fruits and vegetables in place of foods that are high in calories and low in nutrients.

Guide individuals to low-fat diets built from plant foods.

Recommend a very strict diet consisting of up to 75 percent raw vegetables.

Recommend a plant-based diet (vegetables, legumes, nuts).

Explain what a serving of a fruit or vegetable is.

Feature fruits and vegetables in any guidelines or advice focusing on fiber.

Integrate and reinforce actionable messages about fruit and vegetables.

Continue to feature oranges in the new *Dietary Guidelines* and supporting Food Guide Pyramid graphic.

Educate Americans about the role that "good carbohydrates," like fresh citrus and other fruits and vegetables, can play in a healthy, balanced diet.

Consumption of Fruit Juices

Stress that pasteurized, 100-percent fruit juice is an affordable, easy source of vitamin C, folate, potassium, and even calcium in fortified juices.

Emphasize that there is no association between feeding fruit juice to children and childhood obesity.

Advise limiting fruit juice, especially for children.

Encourage limiting the consumption of sugars in fruit juices and similar preparations.

Chronic Disease

Consumption of fruits and vegetables is associated with the prevention of lung cancer, coronary heart disease, diabetes mellitus, hypertension, and stroke.

Consider the nutritional benefits of the citrus fruit category as a whole. Fruits offer health-promoting nutrients and phytochemicals that

play a vital role in several life-sustaining functions, including cardiovascular disease and immunity.

Communication

Provide a message about variety, which is particularly critical concerning fruits and vegetables.

Include the concept of color as a way for consumers to practice the concept of variety for both fruits and vegetables. (3)

Dairy/Calcium

Scope

Change the name of the "Milk, yogurt, and cheese group" (Milk group) to "Calcium-Rich Foods Group" and add nondairy calcium sources to the group listing.

Instead of having dairy products as an entire section on the Food Guide Pyramid, either include dairy products in the protein section as one option of a protein source or create a calcium category which can include dairy products as well as other calcium-rich foods, including dark-green leafy vegetables, soy milk, almonds, tofu, fortified orange juice, etc.

Recommend complete elimination of pasteurized dairy products from the *Dietary Guidelines*.

Recommend 3 to 4 servings of milk and dairy products each day. (2)

Content

General

Call for research that shows that dairy products are harmful.

Include dairy desserts in the "infrequently consumed" category.

List dairy products as optional and not preferred or recommended.

Advise people over age 2 years to choose low-fat or nonfat milk products.

Explain that milk and other dairy foods include calcium, phosphorus, riboflavin, vitamin B12, protein, potassium, zinc, magnesium, and vitamin A.

Sources

Explain that both dairy products and calcium supplements positively influence bone mineral density.

Emphasize that dairy foods are the best and most abundant natural source of dietary calcium available to Americans.

Stress that substituting calcium-containing vegetables for dairy foods does not realistically provide adequate dietary calcium intake.

Explain that nondairy sources of calcium are not suitable substitutes for milk.

Explain that there are effectively no dietary substitutes for dairy products, not even soy products.

Include calcium-fortified soy products in the milk group.

Dairy recommendations are inappropriate because of the vast number of people who are lactose intolerant. Make more recommendations for alternative calcium-containing foods, including fortified juices.

Instead of offering suggestions of alternative calcium sources for lactose-intolerant people, offer suggestions on how lactose maldigesters can better tolerate dairy foods.

If recommendations reduce dairy intake to 2 to 3 servings, there must be a concomitant increase in vegetable consumption to make up the difference in calcium intake.

Overweight/Obesity

Discuss the fact that milk, cheese, and yogurt naturally provide a unique combination of nutrients and are an absolutely critical part of the solution for many of today's health problems, including obesity.

Explain that consumption of dairy reduces the risk for overweight individuals of developing Insulin Resistance Syndrome (IRS).

Chronic Disease

Explain that reduction of hypertension and obesity are associated with increased consumption of dairy foods.

Explain that consuming dairy foods reduces the risk of osteoporosis, obesity, cancer, and hypertension.

Stress that there is no association between dairy intake and LDL-cholesterol.

Emphasize that calcium is essential for bone growth and preservation.

Explain that consumption of dairy foods brings health benefits such as bone health, reduced hypertension, and weight management.

Children/Adolescents

Explain that children who drink flavored milk are more likely to meet their calcium requirement through diet than those who drink unflavored milk.

Strengthen the dairy/calcium recommendation for children/adolescents; intake among adolescent girls age 12 to 15 and 16 to 19 years has been inadequate for 30 years.

African American children and adolescents have significantly lower calcium intake than other subpopulations.

Meat/Protein

Scope

Recommend a diet higher in protein than the diet in the *2000 Dietary Guidelines*. (4)

Recommend a diet low in protein relative to the *2000 Dietary Guidelines*. (4)

Reconsideration of any red meat consumption guidelines is warranted because of the changes in the fat content of several cuts of red meat.

Content

General

Reorder the listing of food items in the meat and beans group.

Limit red meat to 3 ounces daily.

Sources

Mandate that meat be labeled as "grass fed" or "grain fed."

Recommend that people eat meat only from grass-fed or free-range animals.

Recommend at least one nonmeat serving from the protein group.

Encourage people to eat less red meat and provide guidelines for selecting lean meats. (2)

Discuss the new qualified health claim for nuts and reduced risk of heart disease and promote the substitution of nuts for other saturated-fat-containing protein.

Separate plant and animal protein sources in the *Dietary Guidelines.*

Include limits on fish known to have high amounts of mercury, especially for vulnerable populations.

Chronic Disease

Be cautious when communicating the research on meat and cancer, being careful to note that any association between preserved meat and cancer is only probable and not convincing.

Reconsider scientific research on meat and cancer risk.

Food Safety

Content

Foodborne Illness Risks

Recommend a diet based on plant foods to reduce the risk of foodborne illnesses.

Call attention to EggBeaters® as an example of a pasteurized egg product that can be safely consumed by any population.

Stress that eating canned foods leaves you at relatively low risk of foodborne illness.

State that listeria is more important to consider for some more vulnerable subpopulations, including pregnant women.

Advise people who eat fish caught by themselves or by family or friends to follow local fish advisories.

Give more specific examples and assistance to consumers to be very careful about foodborne illness.

Food Handling

Under "find ways to include plenty of different fruits and vegetables in your meals and snacks," stress that if a can is opened, the uneaten portion of food should be transferred to a clean container for refrigeration.

Explain that people should refrigerate foods to limit microbial growth.

Include washing techniques (how and when) for hands and surfaces.

Include specific advice on how to keep foods safe, including safe temperatures for specific foods.

Processed Foods

Recommend that manufacturers stop bleaching food and making it addictive with all the chemicals.

Pesticides/Contaminants

Recommend that all foods should be pesticide free.

Encourage organic farming to cut out the hormones and pesticides.

Address the presence of pesticides, metals, and toxins in food.

Address the presence of viral, bacterial, and chemical contaminants in food.

Address chemical contaminants in this section of the *Dietary Guidelines*.

Fats

Scope

Revise the current fat guideline to indicate a clear preference for including unsaturated fats in a moderate-fat diet and an equally clear admonition to avoid saturated fats and high-cholesterol foods: "Replacing foods high in saturated fats, *trans* fatty acids, and cholesterol with foods high in unsaturated fats will reduce blood cholesterol, thereby reducing the risk of coronary heart disease."

Note the main sources of saturated fat and cholesterol in the guidelines: "Choose a diet that is low in saturated fat and cholesterol by avoiding animal products and tropical oils."

Put greater emphasis on the fat guidelines and provide information on the relationship between fat intake and disease.

Eliminate the reference to palm oil from the guideline for the next edition, citing scientific evidence that reveals that palm oil affects serum lipids more like monounsaturated fatty acids (MUFAs) than saturated fats.

Do not set a maximum fat intake; individuals benefit from a diet of 10 to15 percent calories from fat.

Delete "sparingly" in reference to fat intake, or change the recommended fat intake in the *Dietary Guidelines* so that they agree.

Content

General

Do not recommend unscientific opposition to animal fats that are more stable than some other fats (i.e., those that do not easily form free radicals).

Recommend a descriptive label for foods that contain the specified minimum amount per serving of these types of fats.

Advise people to limit the intake of animal fats, to eat lower fat dairy products, and to use cooking methods that allow fat to drain off and be discarded to reduce exposures to pesticides and other chemicals.

Include the statement "Replacing foods high in unsaturated fats, *trans* fatty acids, and cholesterol with foods high in unsaturated fats will reduce total and LDL cholesterol, thereby reducing the risk of coronary heart disease."

The *2000 Dietary Guidelines* should be revised to indicate a clear preference for including fats in a moderate fat diet and an equally clear admonition to avoid saturated fats, *trans* fats, and high-cholesterol foods.

Differences

Provide a discussion on the differences between "good" and "bad" fats. (6)

Distinguish between the different types of fats.

Convey the health differences associated with the different fats to the consumer.

Further differentiate between types of unsaturated fats (i.e., MUFAs and omega-3 fatty acids).

Distinguish *trans* fat (i.e., "manmade" fat) from other fats.

Differentiate between unsaturated fats and the types of fats they contain, such as monounsaturated and omega-3-fatty acids.

Saturated Fats and *Trans* Fats

Do not recommend substitution of stearic acid for *trans* fats in margarine products and *trans* fat content of margarine products. If this substitution were made, the material in the *trans* fat category would be transferred to saturated fat, and because the *Dietary Guidelines* are going to recommend that people combine the two numbers and make their decisions anyway, the substitution is not necessary.

Include *trans* fats in "Choose Sensibly, point #1" of the one-page summary of the *Dietary Guidelines*, along with saturated fats, because the consumption of *trans* fats has a more deleterious effect on atherogenesis and high LDL cholesterol levels.

Do not lump all *trans* and saturated fats together; there are some good and bad in each category.

Provide a discussion about good versus bad fats, elimination of *trans* fat, and an increase in monounsaturated fats and omega-3 fatty acids.

Recommend elimination of the use of hydrogenated oil.

Eliminate all sources of *trans* fat from the diet. (4)

Limit *trans* fat in the diet. (2)

Separate margarine from oils in the guidelines since they contain *trans* fats.

Differentiate between naturally occurring *trans* fatty acids and manmade *trans* fatty acids.

Include a caution in the text of the *Dietary Guidelines* about foods with *trans* fatty acids. (2)

Advise people about how to choose foods low in *trans* fat.

Consider strategies to promote product reformulations to remove *trans* from the diet and consider the practical limitations of product reformulation.

Recognize that naturally occurring *trans* fatty acids, like those found in animal products, are different from manmade *trans* fatty acids and may provide health benefits.

Educate consumers about the need to reduce both saturated fats and *trans* fat simultaneously in the diet.

Other Fats

Recommend consumption of omega-3 fatty acids. (5)

Provide information about omega-3 fatty acids to a confused public. (2)

Emphasize the health benefits associated with the consumption of "good" oils (omega-6 versus omega-3). (3)

Encourage a balance of omega-3s and omega-6s and explain how to achieve the desired balance. (3)

Explain that α-linolenic acid (ALA) from flaxseed is an important source of omega-3 fatty acids.

Convey a positive message about liquid oils and the benefits of unsaturated fats.

Encourage further research in the area of ALA and potential health benefits.

Acknowledge that not all polyunsaturated fatty acids (PUFAs) are equivalent.

Food Choices

Recommend a reduction in the consumption of fried products.

Revise the current guidance on salad dressings to highlight the health and taste benefits; salad dressings and sauces can help achieve increased consumption of fruits and vegetables.

Recommend that consumers choose unsaturated fat and prominently feature the avocado as a food that contains "good" fat.

Explain that foods high in saturated and *trans* fat and cholesterol can be nutrient rich and that there are ways to fit these kinds of foods into diets.

Explain that fat levels in restaurant foods are much higher than home-cooked food in most cases.

Provide advice for choosing foods based on the saturated and *trans* fat levels.

Sugars

Scope

Remove added sugars from food, the Food Guide Pyramid, and the *Dietary Guidelines*. (2)

Recommend a low-sugar diet. (Numerous)

Make sugars a minimal part of the standard American diet. (3)

Eliminate refined sugar from the *Dietary Guidelines* altogether. (3)

Strengthen the sugar statement to "eat a diet low in sugar" instead of "moderate your intake of sugar."

Strengthen the current sugars guideline. (2)

Replace "Choose beverages and foods to moderate your intake of sugars" with "Choose beverages and foods to minimize your intake of sugars." (2)

Word the guideline for sugars, "Limit intake of processed foods and beverages in order to reduce sugar intake."

Content

General

Recommend research to investigate the harmful effects of processed carbohydrates and sugar.

Include sugar in the "limit these dietary components" section of the *Dietary Guidelines*.

Added Versus Naturally Occurring Sugars

Added sugars should not be differentiated from naturally occurring sugars; there is no peer-reviewed, scientific base. (2)

The sugars guideline should reflect sugars intake in the context of the entire diet and deemphasize the concept of "added sugars."

There are contradictions in the *2000 Dietary Guidelines* regarding added sugars. Correct this in the 2005 version of the *Dietary Guidelines*.

Stress that amounts of added sugar discussed in the *Dietary Guidelines* are minimum amounts, NOT recommendations for eating added sugar.

Deemphasize references to added sugars in the text of the *Dietary Guidelines*.

List the amounts of added sugar allowable in the diet in a table, along with the overall caloric intake for the particular added-sugar limit.

Include a recommended upper limit in grams of sugar in an added form to food, not to fruit.

Minimize added sugars in the diet. (2)

Limit added sugars to no more than 10 percent of daily caloric intake.

Eliminate added sugar in the diet. (3)

Nutrient Displacement

Do not discuss nutrient displacement in the *Dietary Guidelines*; there is no validated evidence that demonstrates nutrient displacement due to consumption of added sugars.

Sugar and BMI/Obesity

Do not link sugar consumption and BMI; there is no clear and consistent association between increased intakes of added sugars and BMI or any disease save dental caries.

Stress that obesity is caused by total caloric intake and not the intake of added sugars.

Include a discussion of the relationship between sweetened beverages and obesity and dental caries in children.

Chronic Disease

Link a diet low in processed sugar to improving blood sugar and "curing" diabetes.

Provide information on how a variety of diseases can be blamed on the consumption of sugar.

Consider the metabolic and physiologic implications of sugar alcohols.

Terminology/Definitions

Define sugars with the same precision as fats (the term "sugar" should be used explicitly for sucrose from sugar cane or sugar beets).

Differentiate between the various classes of dietary sugars with the same precision applied to dietary fats.

Glycemic Index

Recommend fewer grains, sugars, and other high-glycemic-index foods.

Sugar Substitutes

Remove aspartame and monosodium glutamate from food.

Sweeten food with natural sugar products instead of artificial sweeteners.

Advocate for the use of xylitol in foods instead of sugars.

Salt

Scope

Make recommendations based on hard outcomes and not on "surrogate outcomes" (i.e., blood pressure).

Word the guideline in regard to salts, "Limit intake of processed foods and beverages in order to reduce salt intake."

Continue to strengthen the sodium guideline; since past *Dietary Guidelines* have had a salt guideline, strong scientific evidence should be required before a guideline can be relaxed.

Content

General

State that most salt is added to foods by the manufacturer and not by the consumer and encourage manufacturers to reduce salt in their products.

Recommend that foods be manufactured with no salt.

Recommend that sea salt be used in place of table salt.

Explain that the issue with salt is not "excess sodium" but rather "deficient potassium," "deficient calcium," or "deficient magnesium"; when consuming enough of these other electrolytes, "salt sensitivity" is lost.

Follow recommendations from the IOM report when setting salt guidelines.

Recommend that salt intake be limited.

Food Choices

Note the unusually high level of salt in restaurant food.

Recommend a reduction in the sodium content in bread products.

The fact that it may be difficult or infeasible to reduce sodium commercially should not drive the DGAC's decisions.

Chronic Disease

Link the intake of sodium with hypertension and then further link that with heart attacks and stroke.

Confront the basic question of whether reducing dietary sodium can be expected to improve health outcomes such as myocardial infarction and stroke.

Stress that current disease/high sodium chloride consumption associations (i.e., hypertension, gastric cancer, asthma, stones, osteoporosis) are not valid and that these diseases are caused by other issues related to sodium chloride consumption (i.e., hydrations, co-excretion of calcium with sodium).

Acknowledge that salt sensitivity is a modifiable risk factor influenced by other dietary components.

Consider the possibility that low-salt diets can cause salt sensitivity.

Explain how limiting the intake of iodized salt could result in an increase in the prevalence of iodine deficiency disorders.

Alcoholic Beverages

Content

Include a warning that drinking alcoholic beverages can negatively affect growth and brain development in children and teens.

Recommend that alcohol consumption be limited, if consumed at all. (2)

Recommend complete elimination of alcohol from the diet.

Resource Materials

General

Dietary Guidelines for Americans: A Historical Overview

Dietary Guidelines: Past Experiences and New Approaches

The National Heart, Lung, and Blood Institute's Conflict of Interest: Why We Need the Data Quality Act

Research in Evidence-Based Practice

Evidence-Based Nutrition Principles and Recommendations for the Treatment and Prevention of Diabetes and Related Complications

Effects of Dietary Patterns on Serum Homocysteine: Results of a Randomized, Controlled Feeding Study

The Effect of Breakfast Type on Total Daily Energy Intake and BMI—Results from the Third National Health and Nutrition Examination Survey

The Importance of Breakfast Consumption to Nutrition of Children, Adolescents, and Young Adults

Demographic and Lifestyle Factors Associated with Body Mass Index among Children and Adolescents

Dietary Intake, Dietary Patterns and Changes with Age: An Epidemiological Perspective

Risk Factors for Advanced Colonic Neoplasia and Hyperplastic Polyps in Asymptomatic Individuals

Cereal, Fruit, and Vegetable Fiber Intake and the Risk of Cardiovascular Disease in Elderly Individuals

Intakes of Plant Foods, Fiber, and Fat and Risk of Breast Cancer—A Prospective Study in the Malmo Diet and Cancer Cohort

Dietary Patterns and Changes on Body Mass Index and Waist Circumference in Adults

Ethnic Differences in Dietary Intakes, Physical Activity, and Energy Expenditure in Middle-Aged, Premenopausal Women: The Healthy Transitions Study

Nutrition Influences Skeletal Development from Childhood to Adulthood: A Study of Hip, Spine, and Forearm in Adolescent Females

Specific Nutrients

Impact of Folic Acid Fortification of the U.S. Food Supply on the Occurrence of Neural Tube Defects Impact of Folic Acid Fortification in the United States: Markedly Diminished High Maternal Serum Alpha-Fetoprotein Values

Low Serum Vitamin B_{12} Levels Are Associated With Increased Hip Bone Loss in Older Women: A Prospective Study

Alfacalcidol Reduces the Number of Fallers in a Community-Dwelling Elderly Population With a Minimum Calcium Intake of More Than 500 mg Daily

Vitamin D Intake Is Inversely Associated With Rheumatoid Arthritis

Effects of Vitamin D Intake in Incidence of Multiple Sclerosis

Complex Multivitamin Supplementation Improves Homocysteine and Resistance to LDL-C Oxidation

Vitamin E Bioavailability From Fortified Breakfast Cereal Is Greater Than That From Encapsulated Supplements

Grains

Dietary Intake and Food Sources of Whole Grains Among US Children and Adolescents: Data from the 1994-1996 Continuing Survey of Food Intakes by Individuals

Ready-to-Eat Cereal Consumption: Its Relationship With BMI and Nutrient Intake of Children Aged 4 to 12 Years

Whole-Grain and Fiber Intake and the Incidence of Type II Diabetes

Whole Grains as a Source of Antioxidants

Whole-Grain Intake May Reduce the Risk of Ischemic Heart Disease Death in Postmenopausal Women: The Iowa Women's Health Study

Becoming Proactive With the Whole Grains Message

Fruits and Vegetables

What Can Intervention Studies Tell Us About the Relationship between Fruit and Vegetable Consumption and Weight Management?

Fruit, Vegetables Dietary Fiber and Risk of Colorectal Cancer

Fruits, Vegetables and Lung Cancer: A Pooled Analysis of Cohort Studies

Intake of Fruit and Vegetables and the Risk of Ischemic Stroke in a Cohort of Danish Men and Women

Effects of Fruit and Vegetable Consumption on Plasma Antioxidant Concentrations and Blood Pressure: A Randomised Controlled Trial

The Effect of Fruit and Vegetable Intake on Risk for Coronary Heart Disease

Fruit and Vegetable Consumption and Diabetes Mellitus Incidence among US Adults

Resolving the Coronary Artery Disease Epidemic through Plant-Based Nutrition

Dairy/Calcium

Dairy Consumption, Obesity, and the Insulin Resistance Syndrome in Young Adults (2)

Calcium Intake, Body Composition, and Lipoprotein-Lipid Concentrations in Adults (2)

Normalizing Calcium Intake: Projected Population Effects for Body Weight

Calcium Intake and Reduction in Weight or Fat Mass

Relation between Calcium Intake and Fat Oxidation in Adult Humans

Calcium Intake and Adiposity

Longitudinal Calcium Intake is Negatively Related to Children's Body Fat Indexes

Lactose Maldigestion is Not an Impediment to the Intake of 1500 mg Calcium Daily of Dairy Products

Dietary Calcium Intake in Lactose Maldigesting Intolerant and Tolerant African-American Women

Research and Public Health Implications of the Intricate Relationship Between Calcium and Vitamin D in the Prevention of Colorectal Neoplasia

Associations of Adequate Intake of Calcium with Diet, Beverage Consumption, and Demographic Characteristics among Children and Adolescents

Estimated Healthcare Savings Associated with Adequate Dairy Food Intake

Dairy Food Consumption and Body Weight and Fatness Studied Longitudinally over the Adolescent Period

Increasing Fluid Milk Favorably Affects Bone Mineral Density Responses to Resistance Training in Adolescent Boys

Milk—Good for Bones, Good for Reducing Childhood Obesity? (Commentary)

Role of Dietary Calcium and Dairy Products in Modulating Adiposity

Mechanism of Intracellular Calcium Inhibition of Lipolysis in Human Adipocities

Calcium Intake and Body Weight

Dairy Calcium Related to Changes in Body Composition During a Two-Year Exercise Intervention in Young Women

Regulation of Adiposity by Dietary Calcium

Calcium and Weight: Clinical Studies

The Role of Dietary Calcium and other Nutrients in Moderating Body Fat in Preschool Children

The Effect of Milk Supplements in Calcium Metabolism, Bone Metabolism, and Calcium Balance

Dietary Modification With Dairy Products for Preventing Vertebral Bone Loss in Premenopausal Women: A Three-Year Prospective Study

Effects of Dairy Products on Bone and Body Composition in Pubertal Girls

The Effects of Bone Calcium Supplementation (Milk Powder or Tablets) and Exercise on Bone Density in Postmenopausal Women

Milk Intake and Bone Mineral Acquisition in Adolescent Girls: A Randomized, Controlled Intervention Study

Bone Mineral Density of Adolescents as Affected by Calcium Intake Through Milk and Milk Products

Calcium Supplementation Prevents Seasonal Bone Loss and Changes in Biochemical Markers of Bone Turnover in Elderly New England Women: A Randomized Placebo-Controlled Trial

Calcium, Dairy Products, and Osteoporosis

Gain in Bone Mineral Mass in Prepubertal Girls 3.5 Years After Discontinuation of Calcium Supplementation: A Follow-Up Study

Milk Intake During Childhood and Adolescence, Adult Bone Density, and Osteoporotic Fractures in US Women

Children Who Avoid Drinking Cow's Milk Are at Increased Risk for Prepubertal Bone Fractures

Fat

The Effect of High- Moderate- and Low-Fat Diets on Weight Loss and Cardiovascular Disease Risk Factors

Effects of an Ad Libitum Low-Fat, High-Carbohydrate Diet on Body Weight, Body Composition, and Fat Distribution in Older Men and Women

An Ad Libitum, Very Low-Fat Diet Results in Weight Loss and Changes in Nutrient Intakes in Post-Menopausal Women

Sugar

The Role of Added Sugars in the Diet Quality of Children and Adolescents

The Scientific Basis of Recent US Guidance on Sugars Intake

Consumption of Sugars and the Regulation of Short-Term Satiety and Food Intake
Defining and Interpreting Intakes of Sugars

Sugars, Energy Balance, and Body Weight Control

Salt

A Clinical Trial of the Effects on Blood Pressure of Reduced Sodium and the DASH Dietary Pattern (the DASH-Sodium Trial)

2004 Canadian Recommendations for the Management of Hypertension: Part III—Lifestyle Modifications To Prevent and Control Hypertension

Specific Diets

Efficacy and Safety of Low-Carbohydrate Diets: A Systematic Review

Appendix G-7: Biographical Sketches of the 2005 Dietary Guidelines Advisory Committee Members

Janet King, Ph.D., R.D., Chair

Dr. King joined Children's Hospital Oakland Research Institute as a lead scientist in February 2003. She also holds appointments as Professor of Nutrition and Professor of Internal Medicine at the University of California, Davis, and Professor Emeritus of Nutrition at the University of California, Berkeley. Previously, she directed the U.S. Department of Agriculture (USDA) Western Human Nutrition Research Center for 8 years. She was a faculty member in the Department of Nutritional Sciences at the University of California, Berkeley, for 23 years and chaired the Department from 1988 to 1994.

Dr. King is internationally recognized for her research of energy and zinc metabolism in healthy adults and pregnant women. In her studies of normal weight and obese women, Dr. King showed that the adjustments in energy expenditure during gestation are dictated by maternal fat stores at conception, demonstrating that maternal nutritional status prior to pregnancy influences pregnancy outcome. This information was the basis for different weight gain standards for underweight, normal weight, and overweight women by an Institute of Medicine (IOM) Committee chaired by Dr. King. Dr. King currently chairs a United Nations University, Food and Agriculture Organization, and World Health Organization (WHO) Joint Committee on Dietary Harmonization. Previously, she served on the Food and Agriculture Organization Expert Consultative Group on Energy Requirements. Dr. King was Chair of the Food and Nutrition Board in 1994 when the paradigm for the new Dietary Reference Intakes was established. She also served as Vice-Chair of the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. She recently served on a special committee of the March of Dimes to establish food-based dietary guidelines for pregnant and lactating women and children younger than age 2 years. She currently is a member of the United Nations International Zinc Consultative Group.

Dr. King has published more than 200 papers and abstracts and has trained more than 50 graduate students, postdoctoral Fellows, and visiting scientists. In addition to maintaining an active research program, she has been committed to translating research findings into policy and practice throughout her career. In recognition of her international and national reputation, Dr. King was elected to membership in the IOM/National Academy of Sciences (NAS) in 1994. She has a Ph.D. in nutrition from the University of California, Berkeley.

Lawrence Appel, M.D., M.P.H.

Dr. Appel is a Professor of Medicine at the Johns Hopkins University School of Medicine. He holds adjunct appointments in the Departments of Epidemiology and International Health (Human Nutrition Division) at the Johns Hopkins Bloomberg School of Public Health. His academic home is the Welch Center for Prevention, Epidemiology, and Clinical Research.

The focus of Dr. Appel's career is the conduct of clinical research pertaining to the prevention of hypertension, cardiovascular disease, and kidney disease through both pharmacologic and nonpharmacologic approaches, typically nutrition based. He has been Principal Investigator of several studies, many of which have influenced healthcare policy. These studies include randomized feeding studies (e.g., the Dietary Approaches to Stop Hypertension (DASH) and the DASH-Sodium trials) and behavioral intervention studies (e.g., the PREMIER trial of comprehensive lifestyle modification). Ongoing research includes two prospective observational studies (the Chronic Renal Insufficiency Cohort (CRIC) Study and the African-American Study of Kidney Disease and Hypertension (AASK) Cohort Study) and two clinical trials (the Omni Heart feeding trial, which tests the effects of different macronutrients on cardiovascular risk factors, and the Weight Loss

Maintenance trial, which tests different strategies to maintain weight loss). To date, he has published more than 100 articles.

Dr. Appel has been actively involved in policymaking committees, including the Nutrition Committee of the American Heart Association (AHA) and several committees of the IOM. The latter include the Committee on Evaluating Coverage of Nutrition Services for the Medicare Population, Committee on Evaluation of the Evolving Science in Dietary Supplements, and Committee on Dietary Reference Intakes for Electrolytes and Water, which he chairs. In addition to conducting clinical research, Dr. Appel directs a class on clinical trials, teaches research methods in journal clubs and other settings, and has mentored numerous faculty members, postdoctoral Fellows, and graduate students. He also is a practicing internist.

Yvonne Bronner, Sc.D., R.D., L.D.

Dr. Bronner is currently a Professor and Director of the Public Health Program at Morgan State University located in Baltimore, Maryland. Previously, Dr. Bronner held faculty positions at the Johns Hopkins Bloomberg School of Public Health in Baltimore, Maryland, and Howard University in Washington, DC.

Dr. Bronner holds a B.S. in food and nutrition from the University of Akron in Akron, Ohio, an M.S. in nutrition and public health from Case Western Reserve University in Cleveland, Ohio, and a doctorate in science, with a concentration in maternal child health from Johns Hopkins University in Baltimore, Maryland.

Since 1985, she has been a leader in promoting breastfeeding. She served as chair of the research committee for a 5-year community-based breastfeeding promotion project in Washington, DC. Dr. Bronner developed and taught among the Nation's first courses in a school of public health that trained practicing physicians, nurses, and social workers on how to counsel expectant and new mothers on breastfeeding. Dr. Bronner also led the team that developed the only set of materials (video, pamphlets, and posters) devoted to encouraging African American males to support breastfeeding. The development of these materials was supported by the USDA Food and Nutrition Service, and more than 75,000 copies have been distributed nationwide. She also supports WHO efforts to increase the number of "baby-friendly" hospitals, which substitute breastfeeding support programs for free gifts of infant formula.

Dr. Bronner has more than 20 years of experience in research, training, and program development in the areas of nutrition and maternal and child health. Her work is widely published in peer review journals such as the *Journal of Nutrition Education and Behavior*, the *Journal of the American Dietetic Association*, and others. She is the Chair of the Consortium of African American Public Health Programs and serves on numerous advisory committees, such as the NAS, IOM, Food and Nutrition Board, the Department of Health and Human Services (HHS), Maternal and Child Health Review Panel, and others.

Benjamin Caballero, M.D., Ph.D.

Dr. Caballero is Professor of International Health at the Johns Hopkins Bloomberg School of Public Health and Professor of Pediatrics at the School of Medicine. He is Director of the Center for Human Nutrition at the same institution. He obtained his medical degree at the University of Buenos Aires, Argentina, and his Ph.D. in neuroendocrine regulation at the Massachusetts Institute of Technology in Cambridge, Massachusetts. He completed his clinical training at the Harvard Medical School/MIT Clinical Nutrition Training Program.

Dr. Caballero is a member of the Standing Committee for the Scientific Evaluation of the Dietary Reference Intakes, IOM, and has served on the Food and Nutrition Board and on the Macronutrient Dietary Reference Intakes panel of the IOM. He serves on the Council of the American Society for Clinical Nutrition and is past president of the Society for International Nutrition Research. He also has served as scientific advisor for numerous national and international organizations, including the Food and Drug Administration (FDA), USDA, WHO, and others. His areas of research interest include obesity in children and adolescents, undernutrition, and nutrition and health in developing countries.

Carlos A. Camargo, M.D., Dr.P.H.

Dr. Camargo is an Associate Professor of Medicine and Epidemiology at Harvard University, an emergency physician at Massachusetts General Hospital, and a research epidemiologist at the Channing Laboratory, Brigham and Women's

Hospital—all in Boston, Massachusetts. Since 1982, Dr. Camargo has studied the health effects of moderate alcohol consumption. He has focused on the association between moderate drinking and risk for cardiovascular diseases, such as myocardial infarction and stroke. More recently, he has led research on the epidemiology of alcohol-related injuries and diseases in U.S. emergency departments.

At present, Dr. Camargo's primary areas of research are asthma and chronic obstructive pulmonary disease (COPD). This work includes studies funded by the National Institutes of Health (NIH) on diet, obesity, and risk of asthma/COPD in several large prospective cohorts (e.g., the Nurses' Health Studies).

Dr. Camargo also directs a clinical research collaboration called the Emergency Medicine Network (EMNet). EMNet involves more than 100 U.S. emergency departments (www.emnet-usa.org) and focuses on both respiratory emergencies and public health interventions in the emergency department.

Dr. Camargo has more than 140 peer-reviewed publications and is President of the American College of Epidemiology (*www.acepidemiology.org*). He serves on the NIH study section on Epidemiology of Clinical Disorders and Aging and on other national grant review committees. He also has served on, or chaired, several national committees related to asthma, COPD, emergency medicine, and public health.

Fergus Clydesdale, Ph.D.

Dr. Clydesdale is a Distinguished Professor, head of the Department of Food Science, and Director of the Strategic Research Alliance at the University of Massachusetts, Amherst. He received his B.A. and M.A. from the University of Toronto and his Ph.D. from the University of Massachusetts. Dr. Clydesdale has published about 360 scientific articles and has coauthored or edited 20 books. He has served on numerous committees, including those of the NAS, the Federation of American Societies for Experimental Biology, the U.S. Senate, IFT, ILSI-NA, Codex Alimentarius, the Keystone Committee on National Policy on Diet and Health, the Food and Nutrition Board of the NAS, and the Food Advisory Committee of the FDA, where, among other duties, he served as Chair of the FDA Working Panel to evaluate olestra. He also served three terms as Chair of the Food Forum of the Food and Nutrition Board of the NAS and was a member of the NAS Food Safety Oversight Commission. Dr. Clydesdale currently serves on the National Academy IOM Committee that reviews the use of DRIs in nutrition labeling and on the Institute of Food Technologists (IFT) council. He also is a special consultant to FDA.

Dr. Clydesdale currently serves on several advisory and editorial boards, is past Chair of the IFT's Expert Panel on Food Safety and Nutrition, editor of Critical Reviews in *Food Science and Nutrition*, Vice President of the Board of Trustees of the International Life Sciences Institute, and Chair of the Board of Trustees of the International Life Sciences Institute-North America. He is the recipient of the University of Massachusetts Distinguished Teaching Award and has received many other honors, including the IFT's William V. Cruess Award for teaching, its Babcock Hart Award for research, the Tressler Award, the IFT Carl R. Feller's Award, and the Council for Agricultural Science and Technology's Charles A. Black Award for scientific communication. He also received the IFT's highest honor, the Nicholas Appert Award, and was inducted as an honorary member of the "L'Association Internationale Nicolas Appert."

Dr. Clydesdale was selected as a plenary speaker at the 50th anniversary meeting of IFT, the keynote speaker at the 1987 meeting of the Australian Institute of Food Science and Technology (AIFST), a plenary speaker at the 75th anniversary of the Finnish Meat Institute in Helsinki, and a presenter at the Eighth International Congress in Food Science and Technology in Toronto and the Fourteenth South African International Congress on Food Science and Technology. He has been named a Fellow of the IFT and the American College of Nutrition, an honorary Fellow of the AIFST, and a centennial visiting professor by the Tokyo University of Fisheries. He served as President of Phi Tau Sigma, the food science honors society.

Dr. Clydesdale's research involves the study and regulation of physiochemical changes in food that alter nutritional bioavailability, physiological effects, food quality, food acceptability, overall health, and quality of life. This interest provides a unique perspective because it combines food science, nutrition, public health, and consumer acceptance.

Vay Liang W. (Bill) Go, M.D.

Dr. Go is a Professor of Medicine, David Geffen School of Medicine, at the University of California, Los Angeles (UCLA). He is an internationally renowned scientist and clinical investigator, an active and effective administrator, and an outstanding medical editor.

He was born in Ozamis City, Philippines, and received his medical degree from the University of Santo Tomas in 1963. He received his internal medicine and gastroenterology training at the Mayo Clinic, Rochester, Minnesota, and became a Professor of Medicine at the Mayo Clinic.

From 1975 to 1985, he co-established and directed the National Cancer Institute's (NCI's) Serum Immunodiagnostic Bank Program at the Mayo Clinic. This is the world's largest serum bank used by NCI in evaluating various tumor markers in diagnosing, prognosticating, and monitoring values in treating the various cancers evaluated by both NIH extramural and intramural programs. From 1985 to 1988, Dr. Go served simultaneously in three related capacities at NIH: (1) Director, Division of Digestive Diseases and Nutrition, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK); (2) Chairman of the Nutrition Coordinating Committee, Office of the Director, NIH, a position that has oversight responsibilities for trans-NIH biomedical and behavioral nutrition research and training; and (3) Executive Secretary of the Federal Interagency Nutrition Coordinating Committee, Office of the Assistant Secretary of Health, HHS, with key responsibilities for the Federal nutrition policy and other legislative nutrition agendas affecting trans-Federal agency programs.

From 1988 to 1992, Dr. Go was Executive Chair, Department of Medicine, at UCLA, providing academic leadership and stewardship of the Medicine Program in Research, Education, and Practice at eight academic medical centers. In 1993, he became Associate Director of the NCI-funded Clinical Nutrition Research Unit, Director of the UCLA Nutrition Education Program, and Co-Principal Investigator of the Nutrition Curriculum Development grants and the Cancer Prevention Curriculum program at UCLA. In 1996, Dr. Go cofounded the UCLA Center for Human Nutrition with Dr. David Heber. The Center provides leadership in nutritional sciences at UCLA by facilitating interdisciplinary research, providing patient care, and creating educational initiatives for health professionals and the public. Since 2003, Dr. Go has been Chair of the Scientific Advisory Board of the Hirshberg Foundation, coordinating pancreatic cancer research programs at UCLA.

In addition, Dr. Go cofounded and was past president of the American Pancreatic Association and is the founding editor and current Editor-in-Chief of the journal *Pancreas*, the official journal of the Japan Pancreas Society and the American Pancreatic Association. He has received numerous honors and recognition awards: Research Achievement Award, American Institute for Cancer Research (2001); Lifetime Achievement Award, American Pancreatic Association (2001); Mayo Foundation Distinguished Alumnus Award (2002); and American Gastroenterological Association/Miles & Shirley Fiterman Foundation Hugh R. Butt Award for Distinguished Achievement in Clinical Research in Hepatology or Nutrition (2003).

Penny Kris-Etherton, Ph.D., R.D.

Dr. Kris-Etherton has been a member of the nutrition faculty in the Department of Nutritional Sciences at the Pennsylvania State University since 1979 and currently is Distinguished Professor of Nutrition. Her research program focuses on understanding the role of diet in the development of cardiovascular disease. She conducts controlled feeding studies that are designed to evaluate the effects of diet and specific nutrients on established and newly defined risk factors for coronary heart disease. Dr. Kris-Etherton is a Fellow in two AHA Councils (arteriosclerosis, thrombosis, and vascular biology, and nutrition, metabolism, and physical activity) and serves on the AHA Nutrition Committee as the American Dietetic Association (ADA) liaison. She served on the Macronutrient DRI panel of the Food and Nutrition Board of the NAS and on the Committee on the Use of DRIs in Nutrition Labeling.

Dr. Kris-Etherton is a member of the Pennsylvania Cardiovascular Health Consortium Executive Committee, a statewide effort to reduce coronary heart disease. She is serving on the ADA committee that is reviewing the *Medical Nutrition Therapy Evidence-Based Guide for Hyperlipidemia*. She has authored or coauthored more than 130 publications on diet and cardiovascular risk factors. Presently, Dr. Kris-Etherton is treasurer of the American Society of Nutritional Sciences (ASNS). She is the

recipient of the Lederle Award from ASNS and the ADA Foundation Award for Excellence in Research.

A graduate of Rochester Institute of Technology, Dr. Kris-Etherton received an M.S. in nutrition from Case Western Reserve University and a Ph.D. in nutrition from the University of Minnesota. She was the Katharine McCormick Scholar at Stanford University, where she completed a postdoctoral research fellowship in lipid metabolism.

Joanne Lupton, Ph.D.

Dr. Lupton is a Regent's Professor and University Faculty Fellow at Texas A&M University and holder of the William W. Allen Endowed Chair in Human Nutrition. She was the founding Chair of the Nutrition Faculty at Texas A&M and has received the Vice Chancellor's Award for Research and the Association of Former Students Award for Teaching from Texas A&M. Dr. Lupton has chaired the Macronutrient DRI panel for the Food and Nutrition Board, NAS, from 2000 to the present. She also chaired the panel to determine the definition of dietary fiber (Food and Nutrition Board, NAS, 2001). She is a lifetime associate of the NAS.

Dr. Lupton is an associate editor of *The Journal of Nutrition* and of *Nutrition and Cancer* and a councilor of the American Society for Nutritional Sciences (ASNS). She is program leader for nutrition, physical fitness, and rehabilitation for the National Space Biomedical Research Institute. Dr. Lupton's research is on the effect of diet on colon physiology and colon cancer, with a particular focus on dietary fiber and omega-3 fatty acids. She has authored or coauthored more than 100 publications and 4 book chapters on diet and colon physiology and has mentored more than 50 graduate students. In 2004 she received the ASNS/Dannon Institute Mentorship Award. She has served on the Nutrition Study Section at NIH and as a visiting scientist at the FDA, where she received the FDA Commissioner's Special Citation for her work on the Task Force on Consumer Health Information for Better Nutrition. Her undergraduate degree is from Mt. Holyoke College, and her Ph.D. in nutrition is from the University of California at Davis.

Theresa Nicklas, Dr.P.H., M.P.H.

Dr. Nicklas is Professor of Pediatrics at the USDA's Agricultural Research Service Children's Nutrition Research Center at Baylor College of Medicine, Department of Pediatrics. Previously, she was Chair and Professor of the Department of Food and Nutrition at North Dakota State University for 2½ years.

Dr. Nicklas has 14 years of experience in spearheading the dietary studies of the Bogalusa Heart Study, and she continues to be an active consultant for this premier study. The Bogalusa Heart Study, which began in 1973, is an epidemiologic investigation of the early natural history of cardiovascular disease and the environmental determinants in a biracial pediatric population. She was chairperson of the school nutrition intervention working group of the multicenter trial called the Child and Adolescent Trial for Cardiovascular Health, which was implemented in 96 schools across 4 states. She was Principal Investigator of a 4-year NIH grant focusing on increasing fruit and vegetable consumption by high school students. One of her current research interests is looking at eating patterns associated with or predictive of obesity between childhood and young adulthood. She also is studying the environmental influences on eating habits of preschool children. Dr. Nicklas has served as a consultant to the U.S. Army Research Institute; to USDA; and for organizations in Hungary, Taiwan, Australia, and New Zealand. Dr. Nicklas has published more than 150 scientific papers, 6 book chapters, and 5 monographs. Her areas of expertise are cardiovascular health and nutritional epidemiology, child nutrition, and health promotion and chronic disease prevention.

Russell Pate, Ph.D.

Dr. Pate is a native of upstate New York and received a B.S. from Springfield College and an M.S. and a Ph.D. from the University of Oregon. In 1974 he joined the faculty of the University of South Carolina, where he now serves as Professor in the Department of Exercise Science and as an Associate Dean for Research in the School of Public Health. During leaves of absence from the University of South Carolina, he has held positions at the University of Virginia and the Medical College of Georgia.

Dr. Pate is an exercise physiologist, with interests in physical activity and physical fitness in children and the health implications of physical activity. He has published more than 158 scholarly papers and has authored or edited 5 books. His research has been supported by NIH, the Centers for Disease Control and Prevention (CDC), the AHA, and several private foundations and corporations. He heads a research team that currently is supported by more than $2

million per year in Federal and other funding. He coordinated the effort that led to the development of the recommendation on physical activity and public health of the CDC and the American College of Sports Medicine (ACSM). He serves on an IOM panel that is developing guidelines on prevention of childhood obesity.

Dr. Pate has served in several leadership positions with ACSM, and from 1993 to 1994 he served as that organization's President. He is a past president of the National Coalition on Promoting Physical Activity. He is an elected Fellow of the American Academy of Kinesiology and Physical Education, and he has served since 1988 as an appointed member of the South Carolina Governor's Council on Physical Fitness. In 1996 he received the Citation Award from ACSM, and in 1999 he received the Alliance Scholar Award of the American Alliance for Health, Physical Education, Recreation, and Dance.

A lifelong distance runner, Dr. Pate competed in 3 U.S. Olympic Trial marathons and twice placed among the top 10 finishers in the Boston Marathon. For more than 20 years, he served as president of the Carolina Marathon Association, which hosted the U.S. Olympic Trials in the Women's Marathon in both 1996 and 2000.

F. Xavier Pi-Sunyer, M.D., M.P.H.

Dr. Pi-Sunyer is Director of the Obesity Research Center and Chief of Endocrinology, Diabetes and Nutrition, St. Luke's-Roosevelt Hospital Center, and Professor of Medicine at the College of Physicians and Surgeons, Columbia University, New York. He is a Senior Attending Physician at St. Luke's-Roosevelt and at New York Presbyterian Hospitals. Dr. Pi-Sunyer is also Professor of Applied Physiology at Columbia Teachers College and on the faculty of the Institute of Human Nutrition at Columbia University College of Physicians and Surgeons.

His research interests are in the hormonal control of carbohydrate metabolism, diabetes mellitus, obesity, and food intake regulation. He has more than 450 publications in these areas and 2 books. Dr. Pi-Sunyer is a past president of the American Diabetes Association, of the American Society for Clinical Nutrition, and of the North American Association for the Study of Obesity. He is a past Councilor of the Society of Experimental Biology and Medicine. He has been honored as a Fellow of NIH's Fogarty International Center. He served on the NIDDK Task Force for the Prevention and Treatment of Obesity and has been a member of numerous NIH study sections and review groups. He was the Chairman of the National Heart, Lung, and Blood Institute Task Force that produced the *NIH Clinical Guidelines on the Identification, Evaluation and Treatment of Obesity*. He has been a consultant to the Federal Trade Commission and is on the Science Board of FDA. He has served on three expert panels of the Food and Nutrition Board of the IOM/NAS. He is a member of WHO's International Obesity Task Force and a member of the New York State Health Research Council. Dr. Pi-Sunyer is on the Steering Committee of the NIH Diabetes Prevention Program and is Co-Chair of the NIH Look AHEAD Trial. He is on the Data Safety Monitoring Board of the National Institute on Aging CALERIE Study. He was Editor-in-Chief of *Obesity Research* from 1997 to 2002 and is an associate editor of the *International Journal of Obesity.*

Connie Weaver, Ph.D.

Dr. Weaver is a Distinguished Professor and Head of the Department of Foods and Nutrition at Purdue University, West Lafayette, Indiana. In 2000, she also became Director of the NIH-funded Botanicals Center to study dietary supplements containing polyphenolics for age-related diseases. Her research interests include mineral bioavailability, calcium metabolism, and bone health.

She was a member of the NAS/IOM Food and Nutrition Board panel to develop new recommendations for requirements for calcium and related nutrients. Dr. Weaver is past president of the American Society for Nutritional Sciences and is on the Board of Trustees of the International Life Sciences Institute. For her contributions in teaching, Dr. Weaver was awarded Purdue University's Outstanding Teaching Award. In 1993 she was honored with the Purdue University Health Promotion Award for Women, and in 1997 she received the IFT's Babcock-Hart Award. In April 2003 she received the USDA A.O. Atwater Lecturership Award at the annual Experimental Biology meeting. She has published more than 160 articles.

Dr. Weaver received a B.S. and an M.S. in food science and human nutrition from Oregon State University. She received a Ph.D. in food science and human nutrition from Florida State University and holds minors in chemistry and plant physiology.

Appendix G-8: Dietary Guidelines Advisory Committee Report Acknowledgments

Lynn B. Bailey, MaurLo Baxter, Christine Bruhn, David M. Buchner, Mona S. Calvo, Janelle W. Coughlin, Gabriel Camano-Garcia, Alicia L. Carriquiry, Shirley Chen, Richard Dengrove, Michael Doyle, Brooke A. Fischer, Richard A. Forshee, James Friday, Janet E. Fulton, Shirley A. Gerrior, Patricia M. Guenther, William Harris, David Haytowitz, Robert P. Heaney, David M. Herring, Frank B. Hu, Majken K. Jensen, Rachel K. Johnson, Wen Yen Juan, Geraldine June, Abby C. King, Harold W. Kohl, Ronald Krauss, Catherine Loria, Kristin L. Marcoe, Linda Lemar, Bess H. Marcus, Richard D. Mattes, Michael I. McBurney, Holly McPeak, Lydia Medieros, Mary M. Murphy, Suzanne P. Murphy, Alvin Nowverl, Eva Obarzanek, Eileen Parish, Eric B. Rimm, Barabara Rolls, Michael N. Sawka, Barbara O. Schneeman, Matthais Schulze, Maureen Storey, Maret G. Traber, Beth Carlton Tohill, Sedigheh-Essie Yamini, Allison A. Yates, Michelle M. Yore, Isabel Walls, Dick Whiting